# SCIENCE ABSTRACTS.

## Section A.—PHYSICS.

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**JANUARY 1919.**

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## GENERAL PHYSICS.

1. *Balance for Rapid Determination of the Densities of Solids.* **J. Gasnault.** (J. de Physique, 6. pp. 291–298, Oct.–Nov.–Dec., 1916.)—Describes a balance by means of which the density of a solid can be read directly on a graduated scale. An ordinary balance has an extension OB on one of the arms OA, the other arm being denoted by OA′. Assuming $OA = OA' = a$ and $OB = b$, we have, if the extension OB is counterpoised, $T\,.\,a = V\,.\,D\,.\,a$, where T is a counterpoise for the body of volume V and density D. If now the body is suspended from B and immersed in a liquid of less density D′, and the counterpoise T remains the same, we have $T\,.\,a = V(D - D')b$. Hence $D\,.\,a = (D - D')b$, and $D = D'b/(b - a)$. From this it follows that to each distance $b$ corresponds a certain density D, and by proper graduation densities can be read off from the scale constructed according to the above equation, correct to two places of decimals, which is sufficiently accurate for many purposes. A. W.

2. *The Ludwik Hardness Test.* **W. C. Unwin.** (Inst. Mech. Eng., J. No. 6. pp. 485–492, Nov.; Disc., No. 7. pp. 493–554, Dec., 1918, and No. 8. pp. 555–597, Jan., 1919.)—Deals with the relationship between indentation hardness-tests of ductile metals. Points out that the variation of the hardness number in the Brinell test with the load and size of ball arises from the fact that the indentations are geometrically dissimilar. In the Ludwik test, this defect is obviated by using for the indenting tool, a right-angled cone.

Martel has established (1) that for a given material the work of indentation is proportional to the volume of indentation and independent (within limits) of the form of the indenting tool; (2) that the pressure causing indentation is at each instant proportional to the area of the indentation normal to the direction of the pressure. If these laws are accepted as true or approximate, the (corrected) Brinell and Ludwik numbers are the same. C. O. B.

3. *Value of Indentation Method in the Determination of Hardness.* **R. G. C. Batson.** (Inst. Mech. Eng., J. No. 6. pp. 463–483, Nov., 1918. Engineering, 106. pp. 475–477, Oct. 25, 1918.)—This paper deals with the determination of hardness by means of the indentation produced by a static load and by the impact of a ball or cone. When a static load is used, a hardness number independent of the diam. of the ball can be obtained by using Moore's formula (Int. Assoc. for Testing Materials, Proc., 1909), based on Meyer's conclusion that the mean pressure per unit area is constant for a given angle of impression, whatever the diam. of the ball. A hardness number independent of the load can be obtained by calculating it from the slope of the "load-depth of indentation" diagram when this diagram becomes straight.

When an indentation is produced by the impact of a ball or cone, it is shown that the energy of the blow is proportional to the volume of indentation. The energy of the blow is proportional to the square of the spherical area of indentation for ball indenting tools only. The volume of indentation, and therefore the dynamic hardness number, is approximately independent of the form of the indenting tool. C. O. B.

4. *Distribution of Energy Stored in Reinforced Concrete.* **H. T. Eddy.** (Frank. Inst., J. 186. pp. 439–448, Oct., 1918.)—Considers the amount of energy stored in reinforced concrete beams and flat slabs, and shows that the conditions are so different in the two cases that it is not possible to compute slabs by beam theory. Uniformly reinforced concrete beams loaded at the one-third points store some 60 % or more of the total energy of flexure in the steel reinforcement alone, and only about half as much in longitudinal compression in the concrete. On the other hand, uniformly loaded flat slab floors with four-way reinforcement store only about 12·5 % of the total energy of flexure in the slab steel. J. W. T. W.

5. *Buckling of Deep Beams.* **J. Prescott.** (Phil. Mag. 36. pp. 297–314, Oct., 1918.)—Gives the mathematical theory of the bending of a deep beam under various conditions of loading and support. The paper is mainly mathematical and cannot be usefully abstracted. J. W. T. W.

6. *Periods of Lateral Vibrations of Loaded Shafts.* **H. H. Jeffcott.** (Roy. Soc., Proc. 95. pp. 106–115, Oct. 7, 1918.)—The author obtains for this problem a determinantal equation such that, in general, the *n* whirling speeds are its roots. In any particular application numerical values may be substituted for the masses, their positions, and the elastic constants of the shaft. The roots of the resulting numerical determinantal equation may be evaluated by successive approximation. Usually not more than the first two or, possibly, three speeds are required.

This determinantal method, although tedious when the number of isolated masses is great, is straightforward and exact. It may be made to take account of variations of shaft diameter, and also of the moments of inertia of the loads, and of different bearing conditions. It is quite general and makes no assumption of an approximate displacement curve of gravitational or other type. E. H. B.

7. *Evaporation of Small Spheres.* **I. Langmuir.** (Phys. Rev. 11. pp. 368–370, Nov., 1918.)—The evaporation of small spheres of iodine in quiet air has been studied by H. W. Morse [see Abs. 1289 (1910)]. Spheres of about one millimetre diameter were placed on the flat pan of a micro-balance and

weighed at intervals until they disappeared. The rate of loss of weight was proportional to the *radius* of the sphere and not to its *surface*.

The author now applies to this problem a theory he had previously developed respecting the passage of heat from small wires in air and other gases in which it appeared that there was a film of stationary gas round the wire. The results support the theory that the evaporation of the small spheres of iodine is determined simply by the rate of diffusion through the surrounding air, and that no allowance need be made for air currents. [See Abs. 1974 (1918).] E. H. B.

8. *Droplet Moving with Variable Velocity in Air*. **R. B. Abbott.** (Phys. Rev. 11. pp. 381–395, Nov., 1918.)—This research, which is both mathematical and experimental, was undertaken to find the law of motion of a droplet moving with variable velocity in a viscous medium, air, as in the Millikan experiment. It is concluded that the assumption that the vertical component of the velocity of a falling droplet oscillating horizontally in an alternating field is constant throughout the complete cycle, is verified. The resistance of the air is proportional to the speed of the droplet. E. H. B.

9. *Theory of the Brownian Motion and Statistical Mechanics*. **L. S. Ornstein** and **F. Zernike.** (K. Akad. Amsterdam, Proc. 21. 1. and 2. pp. 109–114, 1918.)—J. D. van der Waals, Jr., and A. Snethlage have raised objections based on statistical mechanics against the usual deductions from Einstein's formula of the Brownian motion. These objections are thus formulated:—(1) The introduction of a resistance on an emulsion particle proportional to its velocity is incorrect, since, according to a well-known result of statistical mechanics velocities and forces are independent of each other, as is apparent from $\overline{v\mathrm{K}}=0$. This independence is seen more clearly if the latter equation is considered to be not only applicable to the average over a canonical ensemble, but even for any group of systems from that ensemble for which the particle has a definite velocity $v$, making $\overline{\mathrm{K}}=0$ for such a group. (2) It is incorrect to apply Stokes' formula to this force of resistance, as it assumes the liquid around the particle to have a motion dependent on the velocity of the particle. This conflicts with statistical mechanics, since from the latter $\overline{vv_1}=0$, where, for instance, for $v$ the velocity of the particle, $v_1$ may be taken for that of a molecule in its neighbourhood. In consequence Snethlage has assumed for the calculation of the persistence of a particle in the Brownian motion, that the surrounding molecules have the usual Maxwellian distribution of velocity. The present authors have here attempted to give a theory of the Brownian motion which escapes these objections. They attempt to show that the above equations are much less far reaching than they appear, whereby objections to the usual theory lose their force. In addition the authors prove that the reasoning employed by the above objectors is fallacious; they also show how in principle the objections which Zermelo has raised to the statistical mechanics of Gibbs may be put aside as well as the molecular theories of Boltzmann concerning the H theorem. The result obtained may shortly be formulated:—That the properties of a group of systems, chosen so that in all of them the suspension particle has a velocity $v$—a $v$ group—are dependent on the time elapsed since the selection. The statistic-mechanical objections to the application of Stokes' law have probably no justification for a real system, but only for the first moment of a $v$-group, that is, at the very time when it cannot yet be made use of to represent the properties of a real system. H. H. Ho.

**10.** *On the Brownian Motion.* **L. S. Ornstein.** (K. Akad. Amsterdam, Proc. 21. 1. and 2. pp. 96–108, 1918.)—M. v. Smoluchowski observed that the function which gives the probability that in the Brownian motion a particle covers a definite distance in a given time is a solution of the equation of diffusion. For cases in which an exterior force also acts on the particles, he deduced a differential equation for the above-mentioned function of probability by a phenomenological method. Later H. C. Burger deduced this differential equation following a method which takes the essence of the function of probability more into consideration. Both deductions do not stand in direct connection with the mechanism of the Brownian motion, and the object of the present paper is to demonstrate that, starting from a relation used by Mrs. de Haas-Lorentz (*ibid.* 20. p. 1482, 1917) to determine the average square of the distance covered, it is possible to determine the function of probability of the Brownian motion. The author sets out to determine these averages by a new method which will show the incorrectness of Snethlage's opinion that Einstein's theory is in conflict with statistical mechanics. Besides the function of probability for the distance, the author also deduces that for the velocity. The chain of thoughts which lead to the results obtained is shown to have great similarity to Rayleigh's deductions, and to the work of Fokker and of Planck. Finally the author observes that no difficulties occur in the extension of his considerations to the Brownian motion of coordinates in systems with an arbitrary number of degrees of freedom. H. H. Ho.

**11.** *Atomic Structure from the Physico-Chemical Standpoint.* **A. W. Stewart.** (Phil. Mag. 36. pp. 326–336, Oct., 1918.)—The theories put forward up to the present with regard to atomic structure have been based mainly on physical data; but since the problem is a two-fold one, it appears possible that further light may be thrown upon it by a consideration of the chemical side of the question. The author mentions seven fundamental facts which must be accounted for by any complete theory of atomic structure. These seven facts are mainly concerned with the emission of $\alpha$- and $\beta$-rays from radio-active substances, and with the existence of isotopic elements.

The author proceeds to describe a model atom which covers the seven points mentioned in the earlier part of the paper. This "atom" possesses certain novel features. It is assumed that the centre of the atomic structure is a group of negative electrons travelling in closed circular orbits. Closely surrounding this negative group lies another series of orbits occupied by positive electrons, which, in some cases, are associated with negative electrons. These orbits are assumed circular also; their extreme diameter may be taken, according to Rutherford's view, as not being greater than $10^{-12}$ cm.; and, as in the Rutherford atom, the mass of the system is assumed to be concentrated in this portion. Further still from the centre, other electrons move in elongated elliptical orbits, their paths being similar to those of comets in the solar system.

The author states that the atomic number of the element and the general character of the atom are governed by the nature of the two inner sections of the atomic system. The external zone of the atom is the portion influenced by normal reactions resulting in chemical change and valency. Numerous illustrations are given in support of the hypothesis. A. B. W.

**12.** *Theory of Brownian Movement.* **J. D. van der Waals, Jr.** (K. Akad. Amsterdam, Proc. 20. 9. and 10. pp. 1254–1271, 1918.)—Most of the methods by which it has been attempted to calculate the mean path of a Brownian particle suspended in a liquid or gas, start by assuming the thermal movement to be subject to friction, in which case the force on the particle may be split up into a part (due to irregular forces) independent of the velocity, and a force of viscosity opposite and proportional to the velocity. Mrs. de Haas-Lorentz was the first to obtain a formula on this basis, using a method devised by Einstein and Hopf for another purpose, viz. $\overline{\Delta^2} = \mathrm{RT/N} \,.\, 1/3\pi\zeta a \,.\, t$, in which $\Delta$ is the deviation in the time $t$ in a definite direction, *e.g.* in the direction of the X axis, $\overline{\Delta^2}$ is the mean value of $\Delta^2$ taken for all the suspended particles in a gm.-molecule containing N molecules, $\zeta$ is the coefficient of viscosity of the medium, and $a$ is the radius of the particle. The $x$-component of the force of friction is here assumed to have the value $6\pi\zeta a\dot{x}$, in accordance with Stokes' formula.

The author shows that the argument by which the above formula for $\overline{\Delta^2}$ is arrived at involves a very problematical assumption and that the calculation by which Langevin arrives at the same result is open to still more serious objection. The author and A. Snethlage [Abs. 985 (1916)], starting with the same fundamental assumption have obtained by kinetic considerations the form $\overline{\Delta^2} = \mathrm{C}/a^2 \,.\, t$, varying inversely as $a^2$ instead of inversely as $a$. Experiments by A. Snethlage, however, showed it to be inconsistent with the observations which were found to be well represented by the original formula. The author, therefore, after consultation with Lorentz, Einstein, Ehrenfest, Ornstein and Zernike started with the simple formula $\ddot{x} = w(t)$ which, interpreted, gives—

$$x = x_0 + \dot{x}_0 t + \int_0^t w(\theta) \,.\, (t - \theta) d\theta.$$

Since $x - x_0 = \Delta$, and $\dot{x}(wt)$ vanishes when averaged for all the particles, it follows that $\overline{\Delta w(t)} = \overline{w(t) \int_0^t w(\theta) . (t - \theta) d\theta}$. It is then shown by argument which appears quite plausible, that when $t$ is not too small, say not less than a second, $\Delta w(t)$ is negative and sensibly independent of $t$. Hence also $\overline{\Delta/tw(t)} < 0$, so that $w(t)$ is of the form $-r^2\Delta/t + s$, where $\overline{s\Delta} = 0$, so that $\overline{\Delta w(t)} = -\overline{r^2\Delta^2/t} = -\mathrm{Q}$, say. Thus $r^2$ is of the form $\mathrm{Q}/b$. Thus the force that acts on a particle at a given instant may be split up into a force of viscosity against the *measurable* movement and a term which is independent of the *measurable* velocity. The splitting up of the force is therefore permissible when it is considered as damping, not the thermal velocity defined by $m\dot{x}^2 = \mathrm{RT/N}$, but the measurable velocity $\Delta/t$. The author suggests that the original formula for $\overline{\Delta^2}$ might very possibly be completely derived if $r^2$ could be calculated from kinetic considerations. An attempt is made to circumvent the obvious difficulty of this by arguments based on fairly plausible analogies. The formula arrived at is $\overline{\Delta^2} = \mathrm{RT/N} \,.\, 1/6\pi\zeta a \,.\, t$, giving for $\overline{\Delta^2}$ half the value of that given by the original one, which latter better represents the experimental results. Criticisms by Ornstein and Zernike of some of the author's arguments are considered and replied to. G. W. DE T.

**13.** *On the Theory of Molecular and Inner Atomic Processes.* **S. Ratnowsky.** (Ann. d. Physik, 56. 7. pp. 529–568, Sept. 10, 1918.)—The important success attained by the quanta theory during recent years through the work of Planck, Schwarzschild, and Epstein, and especially through that of Bohr and Sommerfeld on the theory of series spectra, indicates without doubt the fact that the quanta method affords a means of finding a solution to a problem, in agreement with experience, in nearly all cases where the classical treatment fails. The present author here takes up the study of the physical nature of the effective quantum *h*, whereby insight may be obtained into the physical foundations of the quanta method. He is of opinion that in essence, the quantum is not an energetic in the sense of Planck's presentation, but its nature is to be sought for in the inner constitution of the atoms. From this standpoint those theories are especially of value which deal with the internal configuration of the nucleus-electron system. The author believes that classical statistical mechanics in its use of molecular processes leads to correct results so long as no allowance has to be made for processes involving inner configuration displacements. Such processes, however, whereby the system passes from one stable configuration to another have to be investigated, and the author concludes that the atoms or molecules are not to be regarded as absolutely closed systems, but that interaction between atoms has to be investigated from the standpoint of inner atomic changes. The present paper deals with an attempt, starting from classical statistical mechanics and electrodynamics with assistance from the hypothesis of intrinsic energy, to obtain the essential theoretical quanta relations, and thence to determine to which branch of mechanics the active quanta belong. In order to establish the existence of an intrinsic energy element, the author assumes that there exists an inner connection between the atoms and electrons of a condensed body, which finds its best support in Haber's relationship between the ultra-red and ultra-violet special frequencies. The generally accepted assumption on atomic constitution is adopted, namely, that of a positively charged nucleus with at least one electron. The author's hypothesis is: That among the electrons of an atom there exists one or more which can function as a kind of binding electron, and these possess the property of displacement with respect to the atomic nucleus in cases where the atomic distance is increased. By this electronic displacement, a part of the energy of the nucleus-electron system is set free. The author believes this presentation to afford an elementary foundation for the existence of a special intrinsic energy in a body. In previous work the assumption of the existence of an intrinsic energy has been shown sufficient for the explanation of the thermodynamic behaviour of a body. Further consequences of the theory are now given. It is shown that atomic processes can only ensue when the atoms approach so near that inner atomic influences can come into play. In Part I of the paper it is shown that the relationships between the limiting values of the intrinsic energy and the characteristic constants of the special system investigated, give rise to the hypothesis that the intrinsic entropy of a degree of freedom must be a universal constant. In Part II this hypothesis is proved to hold good for any system. H. H. Ho.

**14.** *Alleged Gravitational Attraction between Revolving Electrons.* **G. A. Schott.** (Phys. Rev. 12. pp. 23–38, July, 1918.)—This is a critical examination, by means of a lengthy and detailed analysis, of Crehore's claim [Abs. 1299 (1917)] to have proved that two electrons, revolving with uniform velocities in circular orbits about positive centres, in addition to their electrostatic repulsion, exert on each other a residual attraction which varies inversely as the square of the distance between the centres, and his legitimate conclusion, if this result be correct, from this residual attraction, in the case of the diamond coming out immensely greater than the gravitational attraction, that the fundamental equations of the accepted electron theory require substantial modification. The author points out that Crehore's procedure of deriving the residual attraction solely from the electric force exerted on an electron, and neglecting the magnetic effect because it is smaller than the electric effect, for low-speed electrons, is of doubtful validity, considering the smallness of the residual attraction. He also shows that Crehore's process of averaging is faulty. A procedure is then formulated, in which these corrections are taken into account, for dealing with Crehore's fundamental equations, which the author verifies, with the exception of some obvious misprints. The taking of the magnetic effect into account from the beginning does not make the investigation more complicated, and it appears that the magnetic effect, although inappreciable on the average for an amorphous body, is not necessarily so for a crystal. A great simplification is, however, effected by omitting at the outset all terms of higher degree than the second in the inverse distance between the centres, in that such terms obviously cannot contribute to gravitational attraction. It is then found that the residual attraction obtained by Crehore between two electrons describing circular orbits with uniform speeds, but incommensurable periods, is replaced by a small residual repulsion, involving the conclusion that the law of action and reaction holds good only as a first approximation. The author observes that from a theoretical point of view this may no doubt be used as an argument for modifying the Lorentz-Larmor equations in some such sense as is suggested by Crehore, but that from an experimental point of view the deviation is probably not of much moment, as it is so minute that it is not likely ever to be detected by experiment, and he does not therefore pursue the matter further in this paper.

G. W. de T.

15. *Calculation of Some Special Cases in Einstein's Theory of Gravitation.* **G. Nordström.** (K. Akad. Amsterdam, Proc. 21. 1. and 2. pp. 68–79, 1918.) —As an application of the theorems deduced in two preceding papers [see Abs. 822 (1918) on the mass of a material system according to the gravitation theory of Einstein, and Abs. 1019 (1918) on the energy of the gravitation field in Einstein's theory], the author now calculates the gravitation field and the stresses for some special stationary systems with spherical symmetry. First the state at a surface of discontinuity will be investigated. Section 1 deals with introductory formulæ. Section 2 investigates the state at a material surface; and section 3 gives a second example of another kind of surface of discontinuity. In section 4 a sphere of incompressible fluid is treated. Section 5 deals with the gravitation field as it may be imagined to exist inside an atom. In the theory of atomic structure of Rutherford-Bohr, difficulties arise from the assumption that in an atomic nucleus of very small dimensions there exist units of charge which have a greater diameter than the atomic nucleus, at least when they are liberated in the form of electrons. Since Einstein's gravitation theory states that the space in a gravitation field when expressed in natural units is non-Euclidic, the question arises whether this theory leaves the possibility of the assumption that the atomic nucleus fills a greater space with a narrow neck or perhaps a space which crosses itself at a certain point. It is shown that Einstein's theory really admits such a distribution of the stress-energy-tensor that the (three-dimensional) space crosses itself at a certain point. The author opines that Einstein's theory opens wide possibilities for explaining the state of the atomic interior.

H. H. Ho.

16. *The Results of the Geometric-structure Theories and those from Analysis by Röntgen-rays.* **W. Voigt.** (Phys. Zeits. 19. pp. 237–247, June 1, and

pp. 446–462, Oct. 15, 1918.)—In section 1 of this paper the author deals with the present importance of the geometric structure theories which have again become prominent owing to v. Laue's observations on the internal structure of crystals. The latter author has demonstrated orientation by direct observation, and thereby afforded the means of classification into a general scheme. The theories of Sohncke, Federow, and Schönflies again come under review. In section 2 the object of the present paper is outlined. Section 3 deals with two kinds of operations for fixing a structure type in relation to a point system. Section 4 discusses the 32 crystallographic groups. The basis for atomic arrangements is the subject of section 5, while their rotatory and screw axes are dealt with in 6. Inversion arrangements are discussed in 7. Section 8 deals with the principle of the arrangement for the 230 types, and section 9 with their diagrammatic representation, this being accompanied by 16 figures. Section 10 discusses grouping according to crystallographic symmetry. In section 11 the general standpoint is obtained for the comparison of observed structures with theory, from which conclusions are drawn with respect to atomic symmetry. Section 12 discusses the structures of some regular crystals which have been obtained by observation, *e.g.* Cu, Ag, Au, NaCl, KCl, ZnS, $CaF_2$; section 13 does the same for some trigonal crystals, namely: Bi, Sb, As, $SiO_2$, graphite. A theoretical explanation is given for the more complex structures of calcspar and dolomite, following which a comparison is made with hæmatite and ruby. The whole is treated in most comprehensive fashion. H. H. Ho.

17. *The Colours Observed in Halo Phenomena.* **S. W. Visser.** (K. Akad. Amsterdam, Proc. 21. 1. and 2. pp. 119–124, 1918.)—In a previous paper the colouring of haloes has been discussed from the theoretical aspect [see Abs. 1113 (1917)]. In the present note the colours seen in 550 coloured solar haloes are discussed without reference to theory. The personal equation of the different observers is found to enter largely into the records obtained and steps are taken to present the results in as reliable a form as possible. The percentage number of times that the following different colours were observed in (*a*) the 22° halo and (*b*) the parhelia and tangential arc is as follows:—

| | White. | Red, Orange. | Yellow. | Green, Blue, Violet. |
|---|---|---|---|---|
| (*a*) | 17·9 | 63·2 | 7·8 | 11·1 |
| (*b*) | 11·9 | 50·0 | 10·3 | 27·8 |

Five observations are noted in which the full rainbow colours were seen together. A remarkable feature is the variation in breadth of the ordinary circle and the tangential arc. The characteristics noted cannot be explained on the simple refraction theory of the formation of haloes. They demonstrate the action of diffraction. J. S. Di.

18. *Free Air Temperatures during the Cold Winter of* 1917–18. **W. R. Gregg.** (Monthly Weather Rev. Suppt. No. 12. pp. 9–12, 1918.)—Comparison of upper air temperature at Drexel, Nebr., in the winter of 1917–18 with the mean of the two previous winters shows that in December a negative departure at the surface was changed into a positive departure at from 2 to 3 km. height. In January on the contrary a departure of — 4·5° C. at the surface increased to — 7·3° C. at 4500 metres height. An explanation of this difference between Dec. and Jan. is found in the direction of the upper winds. In Dec. a warm westerly current prevailed above, while in Jan. a considerable northerly component accounted for the low temperatures. J. S. Di

**19.** *Report on Modes of Air Motion and the Equations of the General Circulation of the Earth's Atmosphere.* **G. P. Paine.** (Monthly Weather Rev. 46. pp. 311–323, July, 1918.)—The object of the author is to classify and analyse fundamental modes of air motion and to ascertain some of the mathematical laws governing general circulation in the earth's atmosphere. The paper is purely mathematical and does not lend itself to an abstract. J. S. Di.

**20.** *Rainbow Brightness.* **C. T. Whitmell.** (Nature, 102. pp. 125–126, Oct. 17, 1918.)—Computing the relative brightness of the red in the primary (P) and the secondary (S) bows by the use of Fresnel's formulæ, with $\mu=4/3$, the author gets the ratio $P/S=2{\cdot}33$. The light of both bows is very considerably polarised in the plane of reflection. Using a Nicol prism, first in and secondly perpendicular to the plane of polarisation, the values $P/S(\text{in})=2{\cdot}49$, $P/S(\text{perp.})=0{\cdot}83$ are obtained. Thus the primary bow is 2·49 times brighter than the secondary when the nicol transmits its maximum of each, but on the contrary the primary is less bright than the secondary when each is reduced by the nicol to its minimum value. Casual observation of the two bows suggests a ratio of P to S greater than the value 2·33 obtained for red light above. This may be due to the fact that the secondary is of greater breadth than the primary and therefore its light is less concentrated. J. S. Di.

**21.** *On Internal Seiches.* **K. Aichi.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 464–478, Oct., 1918.)—The cause of internal seiches in a fluid is ascribed to the variable density of the fluid, and the author advocates the name "density seiches" as being more appropriate. The oscillations of a fluid possessing variable density have been discussed by Love and by Rayleigh, and the main object of the present investigation is to establish a theory of density seiches based on the results of the above after suitable extensions have been made. In section 1 the fundamental equations are established and in section 2 examined. In 3, the assumption is made that the fluid is bounded by a vertical wall, the boundary conditions being then investigated. Section 4 deals with the conditional equation which holds at the free surface. In section 5, the complete solution is given. Sections 6, 7, 8, 9 and 10 deal with special cases. The paper is mathematical throughout. H. H. Ho.

**22.** *Calculation of the Period of the Internal Seiches for Various Lakes and the Sea.* **K. Aichi.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 478–485, Oct., 1918.)—This communication is entirely concerned with data calculated from the formulæ in a previous paper [preceding Abs.]. Ten sets of tables are given. For a sea, whose length is 1000 km., the period is 75 to 96 hours. Streams and tides can influence the upper strata of a sea, and such disturbances give opportunities for the production of internal seiches. H. H. Ho.

**23.** *New Graphic Method in Nautical Astronomy.* **H. B. G.** (Nature, 102. pp. 155–156, Oct. 24, 1918.)—Describes, with diagrams, the principles and use of a diagram for finding readily, by a simple graphic process, hour angle or azimuth at sea. So far as azimuth is concerned, a diagram of this nature, known as Weir's Azimuth Diagram, has been in use for many years, but in that case the hour angle is made use of as a datum, whereas in the new diagram the altitude takes the place of the hour angle as argument; and, since an altitude can be observed at sea with much less trouble than hour angle can be deduced from chronometer time, some labour is saved by its substitution. The diagram is due to G. W. Littlehales, of the U.S. Hydrographic Department. It is based on the formula

$$\text{hav}\,(a) = \text{hav}\,(b \sim c) + \left\{\text{hav}\,(b + c) - \text{hav}\,(b \sim c)\right\}\text{hav}\,(\text{A}),$$

where $a$, $b$, $c$ are the sides of a spherical triangle and

$$\text{hav}\,(\text{A}) = \text{haversine}\,(\text{A}) = \tfrac{1}{2}\,\text{vers A} = \tfrac{1}{2}(1 - \cos \text{A}).$$

If the sides $b$, $c$ be regarded as constants, $a$, A being variables, the above equation can be represented graphically as a straight line. The diagram is based on this fact, and is a square chart, with sides graduated according to the values of a series of natural haversines, by means of which, having given the altitude and declination of a body and the latitude of the place, hour angles and azimuth may be found by inspection. Upon such a chart, by drawing a straight line through two points readily determined, a connection would be established, in one case between the hour angle and zenith distance, in the other between azimuth and polar distance, so that, one of a pair being given, the value of the other could be taken approximately from the chart. Two numerical illustrations are given. A. W.

24. *Limits of an Atmosphere.* **A. Véronnet.** (Comptes Rendus, 167, pp. 528–531, Oct. 7, 1918.)—From kinetic theory and the laws of gas pressure expressions are found for the limiting height of atmospheres of H, O, or N. In the case of the earth, for instance, an atmosphere of oxygen would have the limit 145 km.; one of nitrogen, 166 km. On the sun a hydrogen atmosphere would extend to 4650 km. A planetary table shows surface pressure on most of the planets not far different from that on the earth, but Mercury and Mars have only one-sixth as much and Jupiter 6 times as much. Thus Jupiter's atmosphere would be shallow and high plateaux should be visible through its upper layers (it is suggested that the Red Spot is one of these), but the surface generally would be masked by the atmosphere. Hydrogen would escape from the earth at a height of 47 times the radius. On Jupiter it might rise to 8000 times the radius. On the other hand, it could only reach 4½ times the radius on Mercury and only 8 times the radius on the moon; which latter could always retain oxygen and nitrogen. W. W. B.

25. *The Question of a Possible Variation in the Solar Rotation.* **R. E. De Lury.** (Astrophys. J. 48. pp. 195–203, Oct., 1918.)—Since H. H. Plaskett suggested that there was a variation during the summer of 1915 in the sun's rate of rotation, the present author has persistently claimed that the variation in the spectroscopic measurements could be more probably explained by the presence of haze [see Abs. 108 and 601 (1917)]. His own observations were brought into comparison, and in a more recent paper [Abs. 740 (1917)] Plaskett made use of these for a further test, finding no sufficient reason to abandon his hypothesis. The present paper is a further reply, in which it is urged that only three of the author's observations had been used by Plaskett, and that for other reasons also the conclusions drawn were unjustifiable. The author is convinced that the blended spectrum of haze from terrestrial sources is quite sufficient to account for the anomalies of "velocity" measurement and that there is no sound reason to believe that the sun's rate of rotation varies. W. W. B.

26. *Solar Constant; Smithsonian Expedition to Chile.* **C. G. Abbot.** (Nat. Acad. Sci., Proc. 4. pp. 313–316, Oct., 1918.)—A *résumé* is given of the

various stages in the attempt to justify the view suggested in 1908, that the solar "constant" has short-period variations. L. A. Bauer having found correlation between these observed variations and certain small magnetic disturbances, and H. H. Clayton a similar correlation with air temperature—finding it direct at equatorial stations and inverse at temperate ones—it was considered that regular solar-constant observations would be an aid in forecasting weather, and for this purpose cloudless stations are required. The present paper explains why Calama in Chile is chosen for the purpose, and gives a few details as to the personnel, equipment, and general conditions of the expedition. W. W. B.

**27.** *Spectrum of Corona, 1914 August 21.* **A. L. Cortie.** (Roy. Astron. Soc., M.N. 78. pp. 665–668, Oct., 1918.)—Having photographed the arc spectrum of iron on the same plate, the author deduces wave-lengths of coronal lines by interpolation where iron lines are frequent, and adopts a mean result from three different methods for the red end where iron lines are few. He used too large an image and too narrow a slit, so that the coronal lines, though sharp were very faint. His measures are in fairly good agreement with those of Furuhjelm for the same eclipse and with those of Dyson's memoir. W. W. B.

**28.** *Displacement of Cyanogen Bands in Solar Spectrum.* **J. Evershed.** (Observatory, No. 531. pp. 371–375, Oct., 1918.)—From eight plates the author infers a shift of the cyanogen group near λ3883, amounting at the limb to + 0·008 Å. Rejecting anomalous dispersion, and also line-of-sight motion, which latter would infer that the earth drives away cyanogen gas at all parts of the sun's limb, he considers Einstein's theory of relativity as a possible cause, but comes to the same conclusion as St. John that the results are unfavourable to the theory. He discusses St. John's results, but thinks many of the lines used are "contaminated" with lines of other substances, causing apparent shifts. He prefers to work on the stronger lines and bands which have the same widths and relative intensities in the sun and in the carbon arc, using "positive on negative" micrometer. He finds the cyanogen shift to be only half that required by the relativity theory, while the iron shift is double that required. He suggests want of symmetry in the Fraunhofer lines as a possible explanation. W. W. B.

**29.** *Orbital Distribution of Asteroids.* **K. Hirayama.** (Ann. de l'Observat. Astron. de Tōkyō, Appendices 2, 4, 5, and 6. Nature, 102. p. 253, Nov. 28, 1918. Abstract.)—Asteroids with mean motion less than 500″ librate, forming groups near the commensurable points 1/1 (Trojan), 3/2, and 4/3. Those with mean motion greater than 500″ generally avoid libration, forming gaps at 2/1, 3/1, 5/2 and so on. After these deductions the author considers the effect of cosmic dust, of density diminishing with increased distance from the sun; suggesting that this will have a perturbing effect on solid bodies, such as asteroids, but possibly only a disintegrating effect upon comets. He also discusses the stability of the librations produced. The further conclusions about families of asteroids (Koronis, Eos, and Themis) [see Abs. 1050 (1918)] point to Jupiter as the cause of the gradual spreading out of these families from more condensed swarms. [See Abs. 475 (1918).] W. W. B.

**30.** *Perturbations caused by Near Approach of Asteroids.* **W. L. Crum.** (Astron. J. 31. pp. 178–180, Oct. 10, 1918.)—Postponing the general problem of a swarm of small planets, the present paper treats of the perturbations of one small planet by another during the period of close approach, with formal integration of the equations of variation, geometrical representations of approach positions, and numerical calculations of a particular set of perturbations. At first the orbits are assumed to be uniformly described, circular, and in one plane with the sun. Afterwards the necessary modifications for eccentricity are introduced. Numerical values are computed for the case of an asteroid having a radius of less than 100 miles and mean density less than half that of the earth, with radius vector not greater than twice that of the earth. W. W. B.

31. *On the Excess of Outward Motion of the Stars of Class B.* **C. D. Perrine.** (Astrophys. J. 48. pp. 145–153, Oct., 1918.)—On re-examining and classifying the B–B5 stars, the following facts appear: (1) Only one star brighter than mag. 3 is approaching, (2) the proportion of approaching stars increases towards the fainter magnitudes, (3) residual velocities in stars of smaller $\mu$ decrease toward the fainter stars. Of the 852 galactic stars examined, only the B type show a numerical preference for receding velocities; in the non-galactic stars the numbers, etc., approaching and receding are similar to the galactic for classes later than B. Classes F, G, K, M, and the later B type show no real preference. Tables and curves are given; the author's results support the theory that the approaching stars of early class B have entered the region of cosmical matter from outside, and that their velocities have been retarded. There appears to be a progressive increase in the proportion of stars with negative velocities as the stars become fainter, but the proper motions are so small that uncertainty exists. H. F. H.

32. *Absorption Correction to Stellar Magnitude.* **F. de Roy.** (British Astron. Assoc. J. 28. p. 252, 1918. Nature, 102. p. 133, Oct. 17, 1918. Abstract.)—Inconsistent observations of the brightness of Nova Aquilæ suggested to the author that perhaps observers had neglected atmospheric absorption. He gives a table showing the correction to reduce apparent magnitudes at various altitudes to the zenith which is the standard in photometry. The correction only reaches 0·1 magnitude at Z. D. 47°; 0·2 at 58°; 0·3 at 64°; 0·4 at 69°; 0·5 at 72°. It amounts to a whole magnitude at 80°, two at 86°, and three at 88°. W. W. B.

33. *Orbit of Spectroscopic Binary p Velorum.* **R. F. Sanford.** (Lick Observat., Bull. 9. [Circ. No. 315], pp. 181–183, 1918.)—Nine spectrograms taken with 3-prism dispersion in 1903–07, and 28 with 2-prism dispersion in 1913–17, all obtained at the Observatory of the D. O. Mills Expedition, are used to determine the orbit. The period given is 10·210955 ± 0·000062 days. Eleven of the plates are used also for the secondary star, and the elements of its orbit deduced. The resulting mass ratio is 1·23, and the dimensions of the orbits are worked out on the hypothesis that the mass of the primary is about three times that of the sun (in accordance with Russell's average value for F stars). Some of the best of the spectrograms are examined by Adams and Joy to determine absolute magnitude. This comes out at 1·9, the visual magnitude being 4·1. The resulting parallax is +0·036″. W. W. B.

34. *Globular Clusters: Distances, Distribution, and Dimensions.* VII. **H. Shapley.** (Mt. Wilson Solar Observat. Contrib. No. 151. Astrophys. J. 48. pp. 154–181, Oct., 1918.)—The author in this, the seventh paper of his

series, applies his method of analysis [see Abs. 1238 (1918)] to the 69 recognised globular clusters. A few parallaxes are obtained directly from the periods and magnitudes of Cepheid variables, and these are compared with similar determinations from magnitudes and from diameter of clusters, showing a satisfactory accordance and providing a standard scale. Twenty-eight of the clusters are then investigated by magnitudes and diameters, and the remaining 41 by diameters only. The distances range from 6500 to 67,000 parsecs, the brightest stars in the most distant clusters being fainter than the 17th photographic magnitude. The average probable error of a parallax is of the order of 20 %, varying with the method used and the quality of observation. Points of the methods are discussed and also comparative accuracy, maximum luminosities, and frequency of giant stars.

The next section deals with distribution in space. There appear to be no globular clusters in the denser stellar regions, so that they are subordinate to the general galactic system. An approximate position is found for the centre of the system of globular clusters.

The concluding portion is reserved for a tentative determination of the actual dimensions and a plate is given with *réseau* intervals of five million astronomical units, for the system Messier 8, whose distance is a quarter of an English trillion (French or American pentillion). It is suggested that the mass of a typical globular cluster is from 250,000 to 500,000 times that of the sun. Messier 8 may be two or three million times as massive as the sun.

W. W. B.

35. *Distribution of the Stars.* **H. C. Plummer.** (Roy. Astron. Soc., M.N. 78. pp. 668-681, Oct., 1918.)—A discussion based upon H. Nort's reduction of H. Henie's counts on the Harvard map of the sky; the limiting magnitude being 11·0 (visual) or 11·5 (photographic), and the number of stars indicated for the whole sky rather more than a million. An expression is given for the number of stars in any square degree of the sky in terms of galactic coordinates and three zonal harmonics. The author deduces a minimum in Lynx and a maximum (20 stars more per square degree) in Pavo, a minimum axis within 5° of the galactic pole, a maximum axis within 2° of the galactic plane, and the intermediate axis in the direction of the vertex. The vector diagram of the distribution in the galactic plane is a three-lobed figure resembling Strömberg's figure of the radial velocities of giant stars, but turned through a right angle. Zonal harmonics deduced from Van Rhijn's counts between 7th and 16th photographic magnitude show a fair agreement. A note is added on the total light of the stars.

W. W. B.

36. *Nova Aquilæ. Dark Line Spectrum.* **J. Lunt.** (Nature, 102. p. 194, Nov. 7, 1918.)—Apart from the bright and dark H spectrum in process of development the spectrum was continuous (June 10–12), but crossed by a true absorption spectrum principally of Ti, Fe, Cr, Sr, Ca, Mg, and He, displaced towards the violet by an amount representing a velocity of 1500 km. per sec., regarded as a true Doppler-effect due to actual motion. The dark H and K (calcium) lines were hardly displaced at all in comparison and the author is inclined to attribute them to a nebulous mass in the line of sight. A second set of dark H and He lines on June 15 showed a displacement equivalent to 2286 km. per sec. **J. Lunt.** (Observatory,

41. No. 582. pp. 408–409, Nov., 1918.)—Confirmation of the high velocity of 2286 km. per sec. from observations on June 15 is found in measures by J. Bosler, indicating 2800 km. per sec. W. W. B.

**37.** *Number of Spiral Nebulæ.* **H. D. Curtis.** (Am. Phil. Soc., Proc. 57. pp. 513–520, 1918.)—This is a further attempt to account for the varied estimates of the total number of spiral nebulæ [see Abs. 751 (1918)]. The number of spiral nebulæ per square degree differs in different galactic latitudes, so that very different inferences may be drawn from partial counts, according to the distribution of the sample areas. The present paper recognising the importance of this, subdivides the material into galactic zones and treating these separately (45° N. to 90°; 45° S. to 90; ± 80° to ± 45°, and + 80° to — 80°) arrives at a total of 722,000, as compared with Fath's 162,000 and Perrine's 500,000. Taking into consideration the fact that very small, faint nebulæ will only be seen in the central portion of a plate, the author concludes that the number that could be photographed under the best conditions probably exceeds a million. W. W. B.

**38.** *Alpha Centauri as Spectroscopic Binary.* **J. Lunt.** (Astrophys. J. 48. pp. 182–194, Oct., 1918.)—Having a period of 81·18 years the binary has completed more than two revolutions since La Caille's first measures in 1752, but radial-velocity measures go back only to 1904. The author's diagram of the motion disregards as of small importance the 4 % difference of mass of the two components, and, after discussing the small differences in the orbits computed by Roberts, See and Doberck, he goes on to determine the real motion of the two stars in space. Close approach is predicted for 1987 6 when the stars will appear to be 4″ apart; in 1951 they will be more than 10″ apart and in 1959 less than 2″. The radial velocities will be equal in 1927 and in 1953 will differ by more than 13 km./sec. W. W. B.

**39.** *Number of Spiral Nebulæ.* **H. D. Curtis.** (Observatory, No. 531. pp. 390–391, Oct., 1918.)—Of these objects about 10,000 were known before photography was applied: Keeler's photographic estimate was 120,000, but Perrine, completing Keeler's work, estimated 500,000 within reach of the Crossley reflector, or about a million in all. Fath at Mount Wilson, with the 60-in reflector, considers 162,000 to be within reach of that telescope with one hour's exposure.

The author of the present paper makes a new estimate from the Crossley photographs taken 1898 to 1918, 489 separate regions being counted and tabulated in zones of galactic latitude. The total arrived at is 722,000, on the supposition that the regions were of average density, and the author gives reasons for estimating a total exceeding a million. The frequency within 80° of the galactic plane is only about one-quarter of that in higher galactic latitudes. W. W. B.

## LIGHT.

40. *Diffraction of Light by an Oblique Cylinder.* **T. K. Chinmayanandam.** (Phys. Rev. 12 pp. 314–324, Oct., 1918.)—This paper gives an account of the diffraction phenomena exhibited when light falls obliquely on a transparent cylinder, and also gives a theoretical explanation of the effects observed. If light falls on a transparent cylinder normally, the rays that emerge after refraction and one internal reflection form two parallel caustics whose directions make a definite angle, which for glass is about 45°. If the incidence of light on the cylinder is made oblique, the two caustics are found to approach each other more and more closely as the angle of incidence is increased. At a certain angle of incidence (about 50°, for glass) the two caustics of the emergent rays coalesce, and cease to exist for greater angles of incidence. At and near the stage where the caustics and the accompanying fringes coalesce, the phenomena presented are of particular interest, and may be conveniently studied by mounting the cylinder horizontally on the table of a spectrometer, the collimator slit being also horizontal. Photographs are reproduced. [See Abs. 1140 (1918).] A. W.

41. *Light Scattered by Gases.* **R. J. Strutt.** (Roy. Soc., Proc. 95. pp. 155–176, Nov. 7, 1918.)—A continuation of previous work [Abs. 885 (1918)]. Fuller details are given of the apparatus and methods, and the investigation has been extended to other gases than air. It is found that the light scattered at right angles by gases and vapours is not completely polarised. The vibrations parallel to the existing beam have always an appreciable intensity, which in ordinary cases varies from 1·2 % (pentane) to 14 % (nitrous oxide) of the intensity in the perpendicular direction. Helium is an outstanding case, polarising far less perfectly than any other gas. The measurements give an intensity in the parallel component nearly (though not quite) half as great as that in the perpendicular component. Theory indicates that this is the ratio to be expected if vibration in the helium atom is limited to a direction fixed within the atom, on the assumption, of course, of random orientation to the exciting light. Such an atom is the antithesis of the "spherical" atom or molecule which would give perfect polarisation. The intensity of scattering by the different gases tried varies as the square of the refractivity, within the limits of experimental error, and this was found to hold even for ether vapour, the square of whose refractivity is 27·1.

Saturated vapours, even when very dense, show no increase of scattering power beyond what the density would lead us to expect. If molecular aggregates are formed, they are not numerous enough to show by this method. Liquid ether apparently scatters about seven times less light than the corresponding mass of ether vapour. A. W.

42. *Colours of the Striæ in Mica.* **C. V. Raman** and **P. N. Ghosh.** (Nature, 102. p. 205, Nov. 14, 1918.)—On examining even the most regularly split and transparent pieces of mica by diffuse reflected light, a few fine hair-like and rather irregular lines may generally be seen on the surface. These lines show some very interesting effects when the mica is examined in a Töpler "Schlieren" apparatus. The sheet as a whole remains invisible, but the striæ shine out as brilliantly coloured lines of light, the colours being different for different striæ, and changing in a remarkable manner as the

inclination of the mica relative to the direction of the incident light is altered. For example, a stria at normal incidence may appear crimson, and, as the mica is rotated about an axis in its own plane, become successively purple, green, yellowish-green, yellow, orange, scarlet, green, yellow, and red. The phenomenon is being investigated in detail. The authors regard the striæ as lines at which the thickness of the mica changes in a discontinuous manner, and the luminosity appears to be due to the radiation from the discontinuity acting as a laminar diffracting boundary. For any particular wave-length the radiation is zero if the retardation of the wave-front on either side of the discontinuity differs by an even multiple of half a wave-length, and is approximately a maximum if the difference is an odd multiple of half a wave-length. The detailed mathematical investigation would follow the general lines indicated by Rayleigh in his theory of the Foucault "knife-edge" test [Abs. 673 (1918)]. **Rayleigh** states that the striæ are probably the same as the lines which can be seen by reflections of soda light, as previously described in his note on "Regularity of Structure in Actual Crystals" [Phil. Mag. 19. p. 96, 1910]. A. W

43. *Scattering of Light by Gases.* **C. Fabry.** (J. de Physique, 7. pp. 89–102, May–June, 1917.)—In this paper the author shows how the theory of the scattering of light by gases, which has been given by Rayleigh, leads to an explanation of several celestial phenomena besides accounting for the blue colour of the sky. It appears that the phenomena observed in the case of comets can be accounted for, and that an extremely small gas density is sufficient to explain the phenomena. Other applications are made to the light from the night sky, the zodiacal light, and the solar corona, in all of which the scattering of light by gases seems to be of importance. A. W.

44. *Refraction of Oblique Rays in a Prism.* **H. Erfle.** (Zeits. Instrumentenk. 38. pp. 141–145. Sept., 1918.)—In many works on geometrical optics the figure illustrating oblique refraction through a prism has been ncorrectly shown, the incident and emergent rays OP, OQ (Fig. 1) being shown on opposite sides of the principal section OAB of the prism. In reality, as shown by Uhler [see Abs. 685 (1909)], they must be on the same side (Fig. 2) so that the real angle of deviation is always less than

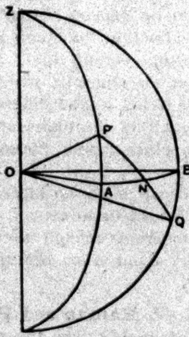


FIG. 1.

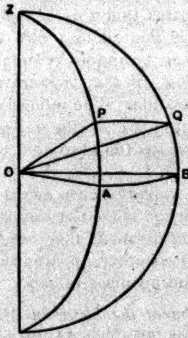


FIG. 2.

the projected angle, and the old formula $\cos \frac{1}{2}D = \cos \frac{1}{2}E \cos \eta$ becomes $\sin \frac{1}{2}D = \sin \frac{1}{2}E \cos \eta$, where $AP = BQ = \eta$, $PQ = D$ and $AB = E$.

The consequent equations are redetermined in accordance with the change.

J. W. T. W.

**45.** *Correction of Telescope Objectives.* **T. Smith.** (Phil. Mag. 36. pp. 405–412, Nov., 1918.)—All the first-order aberrations of any thin objective for light of a given wave-length are determined by three quantities which depend on the refractive indices of the glasses and the curvatures of the surfaces, but not on the position of the object. If these three quantities be denoted by $\alpha$, $\beta$ and $\omega$, the factors which involve the constructional data of the objective in the expressions for the spherical aberration, the coma, and the departure from the sine condition are, respectively,

$$\alpha - 4\beta M + (2\omega + 3)M^2,$$
$$\alpha - \beta(3M + S) + \omega M(M + S) + M(M + 2S),$$

and

$$\alpha - \beta(3M - 1) + \omega M(M - 1) + M(M - 2),$$

where $M = (1 + m)/(1 - m)$ and $S = (1 + s)/(1 - s)$, $m$ and $s$ being the magnifications for the object and the aperture stop respectively. When the objective is a doublet with one air-gap, one additional coefficient will occur in the general expression for $\alpha$, one in the expression for $\beta$, and one in the formulæ for the curvatures of the system in its zero conformation. Thus in the most general case considered by Allen [see Abs. 754 (1918)] only seven quantities are needed instead of fourteen. The accuracy of algebraic solutions is examined and the errors introduced by neglecting the second or the third terms in the expansions for the sine and cosine are tabulated.

J. W. T. W.

**46.** *Bohr's Frequency Condition and Maintenance of the Impulse Moment.* **A. Rubinowicz.** (Phys. Zeits. 19. pp. 441–445, Oct. 15, and pp. 465–474, Nov. 1, 1918.)—The Bohr-Sommerfeld theory of series spectra similar to that of hydrogen is based essentially on two assumptions, namely: (1) That the quanta conditions of the possible electronic orbits give a set of stationary states. (2) A monochromatic light-wave radiates whenever an electron is transferred from one orbit to another, whose frequency $\nu$ is given by the Bohr frequency condition $h\nu = W_A - W_E$, where the latter W's are the corresponding energy values in the quanta states A and E. In the present paper the relationships are discussed for the absence of an external electric or magnetic field, and the consequences are drawn for the further assumption that for the system, "atom + ether," the hypothesis of the maintenance of the impulse moment holds good. Section 1 deals with the connection between emission of energy and impulse moment for an electromagnetic spherical wave. Section 2 investigates the Bohr frequency condition, and the hypothesis of the maintenance of the impulse moment. Section 3 considers polarisation relations, and section 4 the energetic derivation of these for the case of circularly polarised waves.

H. H. Ho.

**47.** *Gallium.* **L. M. Dennis** and **J. A. Bridgman.** (Am. Chem. Soc., J. 40. pp. 1531–1561, Oct., 1918.)—The spark spectra and the arc spectra of gallium, indium, and zinc have been studied, and the delicacy of the spectroscopic detection of gallium and indium alone and in the presence of each other ascertained. With gallium alone it was found possible to detect the presence of 0·0046 mgm. by ocular observation of the spark spectrum. The corresponding amount for indium was found to be 0·0018 mgm. With both metals present the sensitiveness of the method is almost as great as when only one of the metals is present. But observation of the arc spectra, preferably by photographic methods, is quite as good as, if not better than, observation of the spark spectra. The indium line λ4102 and the zinc line λ4811 are just visible when the proportion of these elements to the amount of gallium present is only 0·005 %. The purification of Ga by fractional electrolysis, and the preparation of pure gallium chloride by distillation, are described. Methods have been developed for the determination of Ga alone, and of Ga, In, Zn, and Al in the presence of one another. Two new salts of Ga, namely, gallium selenate and cæsium gallium selenate alum, have been prepared, and the solubilities of ammonium gallium sulphate alum and of cæsium gallium sulphate alum in water, in 50 % alcohol and in 70 % alcohol, have been measured. A. W.

48. *Line Spectrum of Iron Vapour in the Electric Tube Resistance Furnace.* **G. A. Hemsalech.** (Phil. Mag. 36. pp. 281–296, Oct., 1918.)—A continuation of previous work [Abs. 1159 (1918)]. All the results of the experiments carried out in the course of this investigation harmonise with the conclusion that the so-called high-temperature furnace spectrum of iron, which is emitted at temperatures above the boiling-point of this metal, is not caused by purely thermal actions, but requires for its emission the co-operation of electric forces. This conclusion is supported by the following observed facts. (1) The furnace spectrum of iron at 2700° C. is entirely different from the flame spectrum at the same temperature. (2) The relative behaviour of class III lines, especially the group of doublets at λ4957, indicates that the high-temperature furnace spectrum of iron approaches in character that of the arc. (3) Direct experimental evidence has been obtained that an ionisation current will easily pass through iron vapour in a tube furnace. (4) As in the electric spark, the line emission of iron vapour in the furnace does not stop abruptly on the electric field being removed, but continues for some time after, and the extinction takes place gradually, class III lines disappearing first. (5) The spectrum emitted after the current is broken is not controlled by the temperature of the furnace, as is shown by the observation of class III group λ4957 at 2300° C.; no trace of this group is seen in ordinary circumstances even when the temperature of the furnace has been raised to 2400° C. (6) If, instead of completely breaking the current, the latter be reduced to about 180 amps., so that a feeble potential gradient is left on, class III group λ4957 remains visible much longer, and it has been photographed when the temperature had fallen to 2100° C. (7) The absence of a line emission when the vapours of copper, silver, and zinc are subjected to the same conditions, with temperatures up to 2700° C., may be explained by supposing that they possess a low degree of electric conductivity as compared with the vapours of iron, cobalt, and nickel, which easily emit a line spectrum under the same furnace conditions. This supposition is supported by observations on the spark spectra of these metals. (8) The attempt to excite a line spectrum in iron vapour by purely thermal actions in a furnace of special construction gave a negative result. (9) A brilliant line spectrum of iron, similar in character to that observed in the tube-furnace at 2700° C., was obtained with a new type of electric furnace in which a potential gradient of any desired strength could be established. Details of this will be published later. A. W.

49. *Spectrum of Cadmium in the Inactive Gases.* **J. N. Collie** and **H. E. Watson.** (Roy. Soc., Proc. 95. pp. 115–120, Oct. 7, 1918.)—Describes experiments made about ten years ago on the spectrum of cadmium in the gases He, Ne, A, Kr, and Xe. The results are presented in tabular form. Generally speaking, the effects observed were similar in the different gases, but, taking the gases in the above order, it was found that the Cd electrodes melted much more readily in the later members of the series. In the case of helium a current of 5 amps. could be passed in the primary circuit of the induction coil without the discharge tube becoming very hot. In krypton the electrode melted almost at once with a primary current of little more than 1 amp., and in xenon still more easily. In all cases, with very feeble currents, the lines λλ5379, 5338, and 4678 became visible at pressures of 12 mm. or less. On increasing the current, in certain cases, the line λ4800 appeared, followed by λ5086 and then λ6438, this being probably due to the volatilisation of the electrode. With Ne and He the effects were observed at relatively high pressures. In the case of Ne at 60 mm. pressure, two of the Cd lines could be seen, and with He at 40 mm. pressure, four of the Cd lines were visible. The two lines λ5379 and λ5338 were often entirely absent, and the individual lines of the metal varied in a remarkable manner in tubes filled with different monatomic gases when examined under the same conditions of pressure and current density in the discharge. A. W.

50. *Atomic Number and Frequency Differences in Spectral Series.* **H. Bell.** (Phil. Mag. 36. pp. 337–347, Oct., 1918.)—The law of Rydberg, and Kayser and Runge, that the square root of the doublet and triplet differences is proportional to the atomic weights, has been subjected to numerical tests, substituting, however, atomic number for atomic weight. A similar relationship has been found among Kayser and Runge's frequency intervals in the nitrogen column, and a frequency difference of 41·8 cm.$^{-1}$ in the phosphorus spectrum seems to fall into line. A further linearity is indicated for the helium column. It has been found that Runge and Precht's logarithmic law is not an essential improvement. The required correction is apparently necessitated on relativity grounds. It is shown that in two of the columns of the table given there is a two-fold linearity, the lines branching definitely at one of the elements. [See Abs. 1249 (1914) and 1357 (1917).] A. W.

51. *Types of Phosphorescence.* **E. L. Nichols** and **H. L. Howes.** (Nat. Acad. Sci., Proc. 4. pp. 305–312, Oct., 1918.)—The authors propose to recognise two distinct types of phosphorescence, and to designate them (1) *persistent phosphorescence* and (2) *vanishing phosphorescence.* They are sharply distinguished from one another by the following characteristics: (1) This type has a curve of decay made up of a succession of linear processes, of diminishing slope as we proceed from the origin of time. Three or more such processes have been found in all cases which have been studied through a sufficient range. (2) This type has a curve of decay also made up of a succession of linear processes, but of increasing slope as we proceed from the origin of time. In these specifications, the curve of decay is plotted with time from the close of excitation as abscissæ and the reciprocal of the square root of the intensity as ordinates. The presence of linear portions in the curves indicates real changes in the processes by which the emission of light from the phosphorescing body is being maintained. The passage from one process to the next is presumably never actually discontinuous, but it is sometimes very abrupt, as is shown by recent

measurements of the decay of phosphorescence of calcite. It is found that both types may occur in a single substance. For example, the Franklin Furnace calcites exhibit vanishing phosphorescence under ultra-violet excitation and persistent phosphorescence under kathodo-excitation. Both types are obtainable with calcite at any temperature between −180° C. and +800° C. The two types were found to be independent of each other, since the photo-phosphorescence could be superimposed upon the persistent kathodo-luminescence, as a fleeting effect, at any time during the life of the latter, either after or before the close of the kathodo-excitation. Willemite exhibits peculiar features. Masses are occasionally found which exhibit phosphorescence of long duration. Such specimens are persistent under photo-excitation and kathodo-excitation alike. It appears probable that the vanishing phosphorescence exhibited commonly by specimens of this substance may be due to an admixture of calcite. Results have also been obtained which show that not all phosphorescence of quick decay is of the vanishing type, so that the type of phosphorescence is not altogether a question of duration. The willemite of quick decay measured by Waggoner, is, for instance, of much shorter measurable duration than the Franklin Furnace calcites, yet its curve of decay is clearly of the persistent type.

A. W.

52. *Crystalloluminescence.* **H. B. Weiser.** (J. Phys. Chem. 22. pp. 480–509, Oct., 1918.)—The author has studied the phenomenon of the emission of light which accompanies the crystallisation of certain substances from solution and reaches the conclusion that this crystalloluminescence is caused by chemical action. In his opinion nothing is gained by classifying crystalloluminescence as a special case of triboluminescence without explaining this latter phenomenon which the author considers also to be due to chemical action. The luminescent reaction is probably identical in the case of substances that show both triboluminescence and crystalloluminescence, the only difference being in the way in which the reaction is brought about. In the case of the alkali halides the specific reaction which produces the crystalloluminescence is the recombination of the ions, with the formation of the non-dissociated salt. Crystalloluminescence was observed with sodium chloride and with potassium chloride, bromide and iodide, but not with sodium bromide and iodide. A quantitative study was made of the effect of various factors on the intensity of the crystalloluminescence of sodium chloride. When sodium chloride was precipitated by hydrochloric acid, the max. intensity of luminescence was obtained with acid of specific gravity between the limits of 1·115 and 1·125 at 25°. Stirring also is of importance, rapid mixing being necessary to secure the best results. The addition of a colloid, such as gelatine, diminishes the intensity of luminescence, but this decrease is not due to increased viscosity because when the viscosity of the solution was increased by the addition of a non-colloidal substance, such as cane sugar, little effect on the luminescence was observed, at least up to a certain point. The max. intensity of the crystalloluminescence results under conditions which favour the accumulation throughout the solution of the largest possible concentration of ions in excess of the equilibrium concentration; and which allow the luminescent reaction, once started, to go rapidly to completion. The actual conditions which are most favourable differ with different salts. The crystalloluminescence of sodium chloride is bluish white in colour instead of being white light, like an electric spark, as Bandrowski supposed. The colour of the luminescence produced when

sodium is burned slowly in air is similar but slightly bluer than the crystalloluminescence of sodium chloride. The difference is due to the specific effect of the anion. A. F.

53. *Photo- and Kathodo-luminescence of Calcite.* **E. L. Nichols, H. L. Howes,** and **D. T. Wilber.** (Phys. Rev. 11. pp. 351–367, Nov., 1918.)—Experiments made with a large number of samples of calcite from various localities and with reprecipitated calcium carbonate to which small amounts of various impurities were added, tend to the conclusion that the phosphorescent properties of certain calcites are due to impurities. It is possible that the phosphorescent centres are actually calcium oxide, with manganese or other oxide attached in a special manner produced by the heat treatment, and that the calcium carbonate in the calcite crystals is a matrix which holds these few scattered luminescent particles.

Samples of Franklin Furnace calcite were subjected to excitation with the iron spark and also to kathode bombardment. The phosphorescence under photo-excitation is of the vanishing type, ruddy in colour, and of duration about 0·4 sec. Decay curves of the photo-phosphorescence are of the type characteristic of vanishing phosphorescence, previously recorded only in the case of certain uranyl salts. These curves show three "linear" processes. The phosphorescence under kathode-excitation is of the persistent type, red in colour, and is measurable 300 sec. after excitation. Decay curves of the kathodo-phosphorescence are of the more usual type, *e.g.* that of the sulphides. These curves also exhibit a series of linear processes. The red and green regions of the spectrum are both affected by rising temperature, the red attaining a max. intensity at about 70°, whereas the green continues to rise to about 160°. After passing the maximum the fall of both curves is continuous and rapid, and they become too feeble for measurement at about 350°. The differing effects of temperature upon the two regions of the spectrum are indicative of the presence of more than one band in the phosphorescence of these calcites. The components of the spectrum overlap, however, to such an extent as to be indistinguishable by spectroscopic inspection. Spectrophotometric measurements made at 20° and at 200° revealed the presence of two series of overlapping components, one of which is nearly absent at 20°, but is as prominent as the other at 200°. A. W.

## RADIO-ACTIVITY.

54. *Some Properties of the Active Deposit of Radium.* **S. Ratner.** (Phil. Mag. 36. pp. 397–405, Nov., 1918.)—This paper describes an attempt to clear up outstanding difficulties raised by earlier investigators on the behaviour of radium active deposit in electric fields. Reference is made to the work of Russ and Makower [Abs. 382 (1910)], Ratner [Abs. 171 (1918)], Wertenstein (Thesis, Paris, 1912). The main conclusions of the paper may be summarised as follows :—

The experiments now described show clearly that, if the recoil of RaC and RaB does exist in reality, the amount of RaC given up by this process must be vanishingly small, compared with the activity "expanding" from the surface coated with the active deposit. A survey of the work dealing with the questions of recoil of RaC from RaB leads to the conclusion that this phenomenon has hardly ever been observed. The results of the present investigation also throw light on the question of the charge of the recoil atoms. In some of the experiments now described, when the disc has collected about 1/10,000 of the total amount of RaA on the plate no traces of RaB could be found on the disc. Since the presence of RaB in the proportion of 1/20 of the amount of active matter could easily be detected on the disc, it follows that the proportion of recoil atoms of RaB carrying a negative charge is certainly less than 1 to 100,000. This is in wide disagreement with Wertenstein's estimate of 2 to 5 %. A. B. W.

55. *Ratio of Mesothorium to Thorium.* **H. N. McCoy** and **L. M. Henderson.** (Am. Chem. Soc., J. 40. pp. 1316–1326, Sept., 1918.)—Both for scientific and technical reasons a knowledge of the Ms/Th ratio is a matter of considerable importance. The emanation method of determination, as for the Ra/Ur ratio, is not possible in this case. Measurements made by Eve [Abs. 1575 (1908)] on the *total* γ activity of thorianite (without separation of mesothorium), showed that 6·9 × $10^6$ gm. of thorium in a mineral has a γ-ray activity equal to that of 1 gm. of radium. The authors, repeating the measurement by the same method, have confirmed the result. The method, however, is liable to criticism in several respects, and the authors have determined the Ms/Th ratio by an entirely different method. This method was as follows: A determination was made of the β-ray activity of the mesothorium extracted from a known amount of thorium, and the ratio of β- to γ-activity measured for pure mesothorium. The β-activity of the mesothorium could then be expressed in units of γ-activity; and knowing the γ-activity in terms of radium, the amount of Th necessary to produce 1 gm. of mesothorium could be found. The results of a large number of determinations, using different methods of chemical separation, different minerals, and different methods of measurement, are summarised in the following table:—

| | | Ratio Ms/Th |
|---|---|---|
| I. | Thorianite, $BaSO_4$ method | 0·550 × $10^{-7}$ |
| II. | Thorianite, $Al(OH)_3$ method | 0·535 |
| III. | Indian monagite, $Al(OH)_3$ method | 0·507 |
| | Brazilian monagite, ,, ,, | 0·484 |
| IV. | Pure thorium nitrate, $BaSO_4$ method | 0·559 |
| V. | Pure thorium nitrate, $Al(OH)_3$ method | 0·508 |
| | Average = | 0·524 × $10^{-7}$ |

The "$Al(OH)_3$" results are considered more reliable than those from $BaSO_4$.

The total γ-ray activity of mesothorium is shown to be 36·3 % of the total γ-ray activity of thorium in equilibrium with its products. A. B. W.

56. *Thorium Lead.* **O. Hönigschmid.** (Phys. Zeits. 19. pp. 436–437, Oct. 1, 1918. Paper read before the Deut. Bunsen-Gesell, April, 1918.)—A determination of the atomic weight of lead separated from Ceylon thorite, by Soddy, gave a value 207·77; considerably lower than the value 208·0 calculated on the basis of the periods of decay of Ur and Th. Soddy sought to explain this discrepancy by assuming that only 35 % of the thorium-lead is stable, the remaining 65% undergoing further "decay." Lawson attempted to supply an explanation on the grounds that thorite may be a transformation product of thorianite, and by its formation from primary thorianite has estimated the actual isotopic quantities of Ur-lead and thorium-lead.

With the object of throwing further light on this question, the author has undertaken a new analysis of lead from thorite and thorianite. The results of analysis of three "thorianites" are as follows:—

(1) Th and rare earths = 78·2 %, Ur = 11·9 %, Lead = 2·34 %
(2) = 79·11 %, Ur = 12·2 %, Lead = 3·11 %
(3) = 72·52 %, Ur = 18·1 %, Lead = 3·5 %

The values 207·21, 206·91, 206·84 were obtained in cases (1), (2), and (3) respectively, for the atomic weight of the lead. No certain conclusions can be drawn from such results, since the observed atomic weights differ by more than 1 significant figure in the first decimal place from the calculated values. Various possible explanations are offered, but the question is still left open. A. B. W.

**57.** *Isotopic Lead.* **K. Fajans.** (Phys. Zeits. 19. pp. 437–438, Oct. 1, 1918. Paper read before the Deut. Bunsen-Gesell, April, 1918.)—A discussion relating to the atomic weights of lead obtained from different thorium minerals. [See also preceding Abs.] A. B. W.

**58.** *Nomenclature of Radio-elements.* **K. Fajans.** (Zeits. Elektrochem. 23. pp. 250–257, Aug. 1, 1917.)—A discussion of the chaotic state of the nomenclature. Pending an international revision it is proposed to retain the names first used. The prefix "radio" should be indicated by Rd (not by Ra). In the C members and their derivatives the parent C-member is designated by $C_1$, and the $\alpha$- and $\beta$-ray yielding products of the two branches are indicated by $RaC^1$ and $RaC_2$, $AcC_2$ and AcD, and $ThC_2$ and ThD respectively. It would be preferable to use the index *l* (lateral) for the first branch and *on* and *n* for subsequent branches; thus $RaC_1^l$ would be adopted in the place of $RaC_2$. The author does not deceive himself as to the serious difficulties of arriving at any consistent and yet convenient system of nomenclature. H. B.

**59.** *Luminescence due to Radio-activity.* **E. Karrer** and **D. H. Kabakjian.** (Frank. Inst., J. 186. pp. 317–340, Sept., 1918.)—This paper contains an interesting account of the various phenomena observed when $\alpha$-, $\beta$- and $\gamma$-rays from radium excite luminescence in various well-known "screen-materials." Details are given of photometric observations connected with rate of decay of luminescence, life of luminous paints, etc. The original paper should be consulted if specific information is required. A. B. W.

**60.** *Radio-active Properties of Mineral Springs of Colorado.* **O. C. Lester.** (Am. J. Sci. 46. pp. 621–637, Nov., 1918.)—A description of an investigation commenced in 1914. After describing the method of analysis of the mineral waters as regards radio-active content, tables of data are given showing the results of a large number of analyses. In Table I the analyses of 254 springs are given.

Considered as a whole the results given indicate a high average activity, although there are a few springs which are inactive. The most active waters show the highest radio-activity yet found in the U.S.A. The origin of the radio-activity is discussed. A. B. W.

# HEAT.

61. *Study of the Welsbach Mantle.* **H. E. Ives, E. F. Kingsbury,** and **E. Karrer.** (Frank Inst., J. 186. pp. 401–488, Oct., and pp. 585–625, Nov., 1918.)—The investigation here described, in so far as it deals with the radiating characteristics of the incandescent mantle, constitutes chiefly an extension of the work of Rubens on the thoria-ceria mixtures, to a large family of such combinations. It exhibits the Welsbach mantle of commerce simply as one of a group of possible combinations of radiating materials, behaving according to the same general laws, but remarkable among them for the degree to which the characteristics of selective radiation are exhibited. A more detailed study has been made than any heretofore on the behaviour under various conditions of the absorption bands to which the enhanced visible radiation of the more efficient mantles are due. While no explanation has been found for the occurrence of the visible absorption bands of ceria and other materials, the information obtained as to the conditions under which they appear and disappear has made possible a rather complete explanation of some long-standing enigmas, notably that of the different behaviour of the mantle in flame and in kathode-discharge heating. Another line of investigation has been taken up apparently for the first time in any detail, namely, that of the energy relations holding with flame heating of different materials. As a result of the study it has been possible to fix with some definiteness the possible attainable efficiencies of gas-light production by present methods. These, while low, are still many times greater than any now reached. It is shown by the data on the various mixtures of colouring oxides with thoria that their behaviour is in general the same, differing, however, greatly in degree. In all cases an optimum mixture proportion is found. The value of the luminous efficiency at the optimum is greatest for ceria, below which come uranium oxide and neodymium oxide, both exhibiting an efficiency notably above that of the black body. The other oxides dealt with have, at their optimum mixtures, efficiencies too low to be of much interest. The comparatively high efficiency of both the cerium and uranium oxides is due to the presence of a strong absorption band in the blue end of the visible spectrum. In the case of ceria this band is present only when the oxide is hot; in the uranium oxide it is present also in the cold condition. Other oxides—namely, manganese and praseodymium oxides—bleach when hot, thereby partly losing their visible absorption bands, with consequent low efficiency. It appears to be a general characteristic of all the colouring materials to rise in emissive power in the visible spectrum, indicating that the absorption bands, which give visible coloration, have their centres in the ultra-violet region. This is in agreement with their integral visual colour, which is never blue, but always yellow or brown. To this is to be added the very general relative transparency in the infra-red from $1\mu$ to $5\mu$. Both of these characteristics may be to some extent due to the mechanical structure of the mantle. Thus a roughened transparent substance, such as a piece of ground rock-salt, ceases to scatter light when the wave-length becomes long compared with the magnitude of the separate surfaces constituting the roughening; *i.e.* in the infra-red. Also, the absorbing, or scattering, effect of small particles, in

which state the colouring material may be present, decreases with increasing wave-length. One of the most interesting facts brought out by the data is that the colour characteristics of mixtures are not always simply additive. This is exemplified by the extraordinary behaviour of the neodymium mixtures. In their case, however, the new coloration due to the mixture is present only in the cold condition. If it were known how such colours, different from those of the constituents, originated, a new field for the search for colouring materials might be opened.

If the ordinary mantle could be operated at a higher temperature, there would be a very considerable increase in efficiency. The results obtained show that the efficiency of the radiation increases by about three times as the temperature rises from 1900° (regular mantle temperature) to 2100°. This rate of increase is approximately that of the black body, and if continued at the same rate would mean the attainment of an efficiency some 20 times greater at 3000°, which is somewhere near the temperature of operation of the nitrogen-filled tungsten lamp. Actually, the rate of increase of efficiency could be made more rapid, because a progressively larger amount of ceria could be added with advantage at the higher temperature. But with a thoria-ceria mixture the temperature cannot be raised much above 1900° C. without loss of ceria, as ceria melts at 1950° C., and there is good evidence that ceria begins to volatilise at the ordinary operating temperature of the mantle. A. W.

62. *On the Course of the Values of "a" and "b" for Hydrogen at Different Temperatures and Volumes.* (Continuation of the Paper of April 8, 1908.) **J. J. van Laar.** (K. Akad. Amsterdam, Proc. 20. 6. pp. 750–767; 20. 8. pp. 1195–1212, and 21. 1. and 2. pp. 1–15 and 16–25, 1918.)—In the introduction to these four papers the author refers to a communication by van der Waals [see Abs. 236 (1917)], in which the supposition is advanced that the quantity *a* of his equation of state would be dependent on the volume—at least below the critical temperature and for small volumes. In reply to van der Waals' published wish that a serious research should be set on foot above the critical temperature, the author states that he has already worked on this subject for a long time in connection with researches concerning the fundamental values of $\sqrt{(a)}$ for the different elements of the periodic system, in which he found that *a* was chiefly a function of the temperature, whereas *b* appeared to be dependent both on T and on *v*. If, however, *a* were also dependent on *v*, then the equation $a/a_k = \sqrt{(v_k/v)}$ would at least represent the facts equally as well as the equation $a/a_k = 2 - \sqrt{(v/v^k)}$ given by van der Waals. Data for fluorbenzene are given. The author does not consider the theoretical grounds convincing enough on which the latter bases the dependence of *a* on *v*. Section II contains an investigation for hydrogen in which the results appear for the region above the critical temperature. The dependence of *a* and *b* on T are to such a high degree that the suggested dependence on *v* is rendered unnecessary. In section III the values of $a_k$ and $b_k$ at the critical point are obtained. IV deals with the Boyle-point which is of great importance for the study of the *a* and *b* values, and section V with the value of $B = RTb_g - a$ for 20° C. VI contains general considerations on the dependence on temperature. The author concludes that Boltzmann's function of the distribution cannot be maintained, so that an entirely new theory has to be evolved for the calculation of *a* and *b*. In VII the virial of collision on compression of the molecules is obtained. VIII gives the calculation of the values of *a*, *b*, and B, with two tables of data.

IX deals with the influence of the field of force according to Boltzmann, X with the virial of attraction, and XI with the virial of collision. XII gives another derivation of the virial collision. XIII considers objections to the function $e^{-\theta P_r}$ and develops another factor of distribution. In XIV a more accurate theory of the virial of attraction and collision is evolved. In the previous method of calculation, which might in a certain sense be called the "static" method, it is assumed that the molecules are distributed according to a certain law round the considered molecule, whereby their motion, respectively velocity and direction, is entirely eliminated (disregarding the mean final velocity at the collision). In place of this, Boltzmann's factor of distribution $e^{-\theta P_r}$ is then substituted, this being intended to set everything right again. In the author's opinion, however, Boltzmann's considerations are no longer valid for separate micro-complexes, such as molecules in collision, either immediately before impact, or passing each other at a small distance in the sphere of attraction. He is therefore led to a new method of calculation from a dynamic standpoint, and holds that what happens to the molecules that pass each other will have to be considered separately from the case of collision. Thus a return is made from Boltzmann to Maxwell with the consideration of the separate paths or groups of paths, and section XV deals with the fundamental path equations. Sections XVI, XVII, XVIII, and XIX contain the calculation of the virial of attraction and the evaluation of $a$. Section XX discusses the value of $a$ below the limiting temperature. An appendix to the paper deals with the solution of certain integrals which arise.

The paper is mathematical throughout. H. H. Ho.

**63.** *On the Characteristic Equation for Fluids.* **P. Weiss.** (Comptes Rendus, 167. pp. 293–296, Aug. 19, and pp. 364–366, Sept. 2, 1918)—The author defines the internal pressure $\pi$ not as a corrected term for the external pressure $p$, but as the differential of the energy with respect to the volume $v$. If $C_v$ is the specific heat at constant volume, and T the absolute temperature, then from thermodynamics $\partial C_v/\partial v = \partial\pi/\partial T$, and $\dfrac{1}{T}\dfrac{\partial C_v}{\partial v} = \dfrac{\partial\dfrac{p+\pi}{T}}{\partial T}$, from which $\partial p/\partial T = (p+\pi)/T$ and $1/T \,.\, \partial C_v/\partial v = \partial^2 p/\partial T^2$. Throughout the region where the isochors are straight lines $\partial C_v/\partial v = 0$, $\dfrac{\partial\dfrac{p+\pi}{T}}{\partial T} = 0$, and $\partial\pi/\partial T = 0$, from which it follows that $(p+\pi)/T = f_1(v)$, and $\pi = f_2(v)$. The latter is the law of internal pressure, and the previous function the law of dilatation. The author first examines the dilatation law, taking for data the hydrogen isochors deduced from the measurements of Onnes and Braak, these being rectilinear between 68·3° and 169·4°. They give for the dilatation law $v = b + R\,.\,T/p + \pi$, where R is the perfect-gas constant. A relation of slightly modified form is found for carbon monoxide by using Amagat's data between 60° and 100°. In this case R is multiplied by a factor $\zeta$, where $\zeta > 1$, and from the data $\zeta = 1{\cdot}30$. Argon and isopentane are also investigated. Here a species of change of state occurs, the straight lines being in two segments making an angle with each other. All values for the coefficient $\zeta$ which are greater than unity, indicate not association but dissociation of molecules, although the case of argon would exclude this last hypothesis.

In the second paper the author commences with the result that through-

out the region where the isochors are rectilinear the internal pressure is a function of the volume only, and is determined experimentally as the ordinate at the origin of the isochors. For the same family of rectilinear isochors this function has in general a given value which changes for a different family. Amagat and Leduc have shown van der Waals' law to be true at small densities, namely, that the pressure is inversely as the square of the volume; but the present author now shows a more general rule to apply, that is, $\pi=a/v^{\eta}$, where $a$ is a constant and where the exponent $\eta$ may take different values. Several examples are plotted, namely, for isopentane, argon, and ethylene, the abscissæ being taken as the logarithms of $1/v^2$ and the ordinates those of $\pi$. The graph is found to be composed of two lines: an upper line in two segments corresponding to the region of low temperatures and comprising two states characterised by $\eta=2$ and $\eta=1{\cdot}5$, and a lower line, corresponding to more elevated temperatures, which is unique with $\eta=1{\cdot}78$. The juxtaposition of the laws of dilatation and of internal pressure gives the characteristic equation with four constants, $a$, $b$, $\zeta$, $\eta$—namely: $(p+a/v_{\eta})(v-b)=\zeta RT$. This equation represents fluid properties in one of the states corresponding to a family of isochors. [Abs. 1176 (1918) should be consulted.]
H. H. Ho.

**64.** *An Indeterminateness in the Interpretation of the Entropy as Log W.* **[Mrs.] T. Ehrenfest-Afanassjewa.** (K. Akad. Amsterdam, Proc. 21. 1. and 2. pp. 53-57, 1918.)—A certain quantity of a gas may be given, so large that it may be divided into a great number of portions—great enough for the purpose under discussion—without the usual statistical treatment of the parts losing its value. Regarding the matter from a thermodynamic standpoint it is assumed: (1) That the entropy of every system strives to attain its maximum; (2) that the entropy of the total mass of gas is equal to the sum of the entropies of the parts. If, in accordance with the kinetic theory the entropy is taken to be the logarithm of the probability of the state of the system, the following theses are obtained as the analogues of the above:—(1) The state of every system endeavours to approach the greatest probability. (2) The log. of the probability of the state of the total mass of gas is equal to the sum of the logs. of the probability of the states of its parts, or otherwise: the probability of the state of the whole is equal to the product of the states of its parts. It is shown that these theses are only correct provided the combinations reckoned with in the determination of the probability of the state of the whole are submitted to certain limitations, which are quite arbitrary from the combinationary point of view. Examples are given in illustration.
H. H. Ho.

## SOUND.

**65.** *Influence of Amplitude and of Electromagnetic Driving on the Frequency of Tuning-forks.* **D. C. Miller.** (Phys. Rev. 11. pp. 497–498, June, 1918. Abstract of paper read before the Am. Phys. Soc., April, 1918.)—Tuning-forks are commonly considered as having a frequency of one standard value. Only in rare instances is attention given to the influence of conditions of operation and usually notice taken of the temperature effect only. Three other causes produce variations which may be as great as that due to temperature: (*a*) the resonance box, its presence and tuning, (*b*) the amplitude of the prong's vibrations, (*c*) the electromagnetic maintenance of vibration.

Experiments (by means of the Koenig clock-fork) showed that with a type of fork in common use the frequency at 20°, electrically driven with 0·75 mm. double amplitude, was 100·000. When the fork was struck with a felt hammer and allowed to vibrate freely, the frequency at the same temperature and amplitude was 99·975. Thus the electromagnetic driving increased the frequency by about 1 in 4000. While electrically driven, an increase of double amplitude from 0·75 to 2·0 mm. decreased the frequency to 99·990 or 1 in 10,000. E. H. B.

**66.** *Effect of Wind Pressure on Pitch of Pipes.* **A. Mallock.** (Roy. Soc., Proc. 95. pp. 99–106, Oct. 7, 1918.)—Various views have been held as to the manner in which the air jet, or lamina, sustains the vibrations in an organ pipe. To satisfy himself as to what actually occurred, the author made some experiments in which water was substituted for air. A glass tube, about 15 in. long and 1 in. in diam., had at its lower end an ebonite fitting connected to a water supply, and so made as to deliver a lamina of water similar to the air lamina which acts in an ordinary organ pipe. The whole was immersed in a tank until only 3 in. of the tube was above the water surface, thus leaving a column of 1 ft. of water above the orifice of the jet. The natural period of the vertical oscillation of this column would (apart from the influences of the only partially open end and of the jet) have been that of a pendulum 1 ft. long, and slow enough, therefore, to allow of the motions of the jet (made visible by added colour) to be followed by the eye.

The results of the experiments are shown in a graph made by plotting percentage variation of frequency against jet velocity, the law being almost linear.

Rayleigh has carried out a set of experiments on this subject (*Collected Papers*, vol. 2, p. 95), the frequency variation being expressed in terms of wind pressure. The present author puts this in terms of jet velocity. The graph for Rayleigh's experiments is shown for the same coordinates as that for the author's experiments, and the two graphs are seen to be similar. Where the jet velocity is small the frequency is less than the natural frequency, but exceeds it as the velocity increases. In both cases also the character of the frequency curve suggests that there would be a definite limit to the possible increase, though the conditions of experiment prevented that limit being closely approached.

The explanation of the action of the jet in producing the observed results may be put very simply. It is shown that the phase of the displacement of the jet from its central position agrees with that of the velocity of the oscillating fluid, so that its momentum, while tending to increase the amplitude, has no effect of the first order on the period. The jet, however, reacts on the period in two ways. Firstly, it acts as a partial barrier between the interior of the pipe and the air outside, and thus reduces the effective openness of the passage, thereby *lowering* the frequency. Secondly, at the place where the jet breaks up and changes from a laminar form to a convoluted mass of eddies, a certain quantity of the fluid belonging to the oscillating flow is caught up in their folds and accelerated at the expense of the energy of the jet. This tends to *increase* the frequency. E. H. B.

67. *Sounds produced by Drops falling on Water.* **A. Mallock.** (Roy. Soc., Proc. 95. pp. 138-148, Nov. 7, 1918.)—The author had long been interested in the various musical sounds which falling drops produce when they strike the surface of water and, in 1915, made experiments which are here recorded.

The sounds last for a very short time, and to hear them well other noises should be absent. Drops after a shower falling from leaves overhanging a sheltered pond, or the dripping from a tap in a cistern, are some of the commonest examples in which the musical character of the sound can be well distinguished. On listening attentively it will be noticed that the pitch of the note is high at first, then falls and afterwards again rises. The duration of the sound is so short that it is difficult to estimate the actual pitch, but the lowest part of the sound is the most characteristic. It seemed probable that the pitch would be dependent on the resonance of the cavity formed by the impact of the falling drop, and the experiments here described were made with the object of determining the magnitude and shape of the cavity in question. Instantaneous photographs were taken by an electric spark at different intervals after the impact and a number of these are reproduced in the paper. E. H. B.

68. *Theory of Vowels and Application to Auditive Re-Education.* **H. Marichelle.** (Comptes Rendus. 167. pp. 88-91, July 8, 1918.)—Remarks upon the buccal orifice for various vowels, developed in connection with wounded soldiers and their re-education after deafness or faulty speech. E. H. B.

69. *Combination Tones and Overtones.* **E. Budde.** (Phys. Zeits. 19. pp. 321-327, Aug. 1, 1918.)—A theoretical discussion of these topics. [See Abs. 1367 (1916).] E. H. B.

70. *Tempered Scales and Commas.* **G. Sizes.** (Comptes Rendus, 167. pp. 455-458, Sept. 23, 1918.)—Suggests a comma which is the eighth of the equal-tempered tone. E. H. B.

# ELECTRICITY AND MAGNETISM.

## THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

**71.** *Diffraction of Electromagnetic Waves.* **R. Hargreaves.** (Phil. Mag. **36.** pp. 317–319, Oct., 1918.)—Following the suggestion in a letter from J. Larmor, the author shows that his solution of the two-dimensional problem for sound waves [Abs. 1248 (1918)] applies also to electric waves deriving the electromagnetic quantities and the polarisation from the single function there employed. The polarisation being, in general, subject to deflection, the results may be treated, as suggested by Larmor, by the use of short electric waves and a metallic screen. In the two-dimensional problem the function, which for sound is a potential, becomes a stream function. As in the sound problem, the solution may be extended to cases in which the incident wave is such as to involve a third dimension, as is illustrated by an example. In the more general case, however, the function involves something more than is contained in the conception of a stream function as normally employed. G. W. de T.

## DISCHARGE AND OSCILLATIONS.

**72.** *Effect of Heating and Gases on Photoelectric Currents.* **L. A. Welo.** (Phys. Rev. **12.** pp. 251–276, Oct., 1918.)—The gases emitted by silver, gold, nickel, palladium, and platinum at various temperatures up to fusing point are studied, and, after cooling at the various stages, the photoelectric emission is measured. In the stages of high photo-sensitiveness, Ni, Pd and Pt emit only carbon gases or oxygen, whereas hydrogen is emitted at the less sensitive stages. Silver and gold give off H at all heating currents, but in intervals of high sensitiveness the predominating gas gives a carbon spectrum. $CO_2$, N, and possibly H are incapable of protecting the metals from the action of some residual gas in the cell, such as CO or methane. The author discusses the various theories (adsorption, solution, chemical combination, active layers), and indicates further experiments to decide between them. E. E. F.

**73.** *An Attempt to Construct a Theory for Canal Rays.* **G. Huch.** (Ann. d. Physik, **57.** 1. pp. 1–67, Sept. 25, 1918.)—The present investigation attempts a theoretical evaluation of the observations concerning the Doppler-effect for canal rays which have been made by Vegard, Wilsar, etc. Vegard's work is taken for the starting point. Only two new assumptions are made, of which the second is a consequence of the first, namely: (1) That by the impact of two gaseous particles, not only is oscillation energy produced, but there is also an adjustment between the energies present in both radiators before impact in such a way that the energy-content of the radiators tends to an equilibrium. Simple mathematical relationships may be deduced from these assumptions. For instance, the ratio of the static to the dynamic radiation cannot change to a greater value than that of the gas pressures, and the latter changes become smaller, the less the energy lost by the dynamic radiator between two impacts. Vegard's measurements show that for the case of hydrogen a much smaller fraction of oscillation energy is lost between two impacts than for oxygen and nitrogen. (2) The second assumption is that when such an adjustment of energy takes place between radiators in contact, then equal partition will only ensue when they have equal properties, *i.e.* equal oscillation capacities. As an example, from Wilsar's experiments it is shown that the hydrogen particle accepts more energy than do those of nitrogen and oxygen, while the mercury-vapour particle absorbs more energy than those of all other gases investigated. This relationship holds for lines in the visible spectrum, and a different behaviour between atoms and molecules must be expected. The author has found that Stark's work, proceeding from quite different assumptions, leads to an identical outlook for the fundamental oscillation procedure during light-emission. He agrees with Vegard's opinion that the charge on the particles has no essential influence on the emission, and seeks to support this standpoint by an examination of Vegard's charge and energy measurements. The origin of that part of the spectrum belonging to the static part of the gas is investigated. A process is evolved, based on Vegard's experiments on homogeneous canal rays, for estimating the oscillation capacity from the time taken for the light from a gas particle to sink by a definite amount. The author also seeks to solve his problem as a case of a general theory. He develops equations for the case of two gas clouds interpenetrating with a velocity which is very great compared with the velocities of the gas particles relative to each other. The equations for the effects of the canal rays are given as a special case of these generalised equations, where the cloud representing the canal rays is very dilute in comparison with that of the static gas. All the effects are reversed for canal rays of very great density passing through a very dilute gas. The subject is treated in 8 main divisions: (1) The evaluation of Vegard's purely optical measurements; (2) the evaluation of Vegard's energy measurement and Wilsar's experiments; (8) the investigation of the colour ratio on the basis of Lunkenhein's methods. In section 1 of the paper the results of Vegard's investigations are described under: (A) Pure spectrographic experiments on canal rays; (B) dependence of the spectrographic data on the intensities of canal rays; (C) influence exerted on canal rays by magnetic fields. In section 2 the fundamental measurement series is given in diagrammatic form. In section 8, various explanatory experiments are described. Section 4 deals with the assumptions made, and section 5 with definitions. Section 6 discusses the static radiator, and section 7 the dynamic radiator. Section 8 evaluates the ratios of the intensities, while section 9 gives an alternative derivation. Section 10 considers the connection between the intensity ratio and the experimental conditions, under: (*a*) Short light-period for sinking and lack of energy adjustment; (*b*) short light-period with complete adjustment; (*c*) very large sinking period with lack of energy adjustment; (*d*) the same as in (*c*), with complete adjustment. Comprehensive tables and diagrams are given. Section 11 investigates the tension effect. The final section, 12, deals with colour effects.

The paper is mathematical throughout. H. H. Ho.

**74.** *Electric Force in the Mercury Arc.* **C. D. Child.** (Phys. Rev. 12. pp. 277–283, Oct., 1918.)—This paper gives a description of measurements of the electric force in the mercury arc with different temperatures, pressures of vapour, and currents. Similar experiments have been made by others, but in no case are all the data given that are desired. Knipp [Abs. 1480 (1910)] measured the electric force and the pressure of the gas in the apparatus to which the tube containing the arc was connected; but it is desirable to know the pressure in the arc itself, and this is much greater than that which was measured, since the Hg vapour of the arc condenses before reaching the other parts of the apparatus. Measurements of the electric force and of the temperature were made by Wills, and pressures of the gas were computed from the observed temperatures by assuming that the pressure in the arc is the same as that given in tables for the pressure of Hg vapour at different temperatures. Since the vapour in the arc is at a very much higher temperature than that of the liquid mercury in contact with it, this assumption cannot be accepted as correct. Moreover, when testing any theory of the arc, it is necessary to know the density of the vapour rather than the pressure. Since the temperature varies greatly, the density is not proportional to the pressure. There appears to be no way of measuring the density directly, but since the vapour in the arc is far from the point of condensation, it is probable that the density varies inversely as the absolute temperature. As a result, approximate values proportional to the density can be obtained by finding the pressures and the temperature of the Hg vapour. It is, however, difficult to find either of these quantities accurately when the pressure is low. The temperatures can best be measured with a thermo-junction, but even this gives readings which are somewhat too low. When the pressure of the gas is high, the error thus introduced is, no doubt, small, but with pressures in the neighbourhood of 1 mm. it is probably quite appreciable. It is also difficult to measure accurately the pressure of the gas. No method similar to that of the McLeod gauge can be used since the vapour condenses when taken from the arc. Some form of manometer must be used where a surface of mercury is exposed as directly as possible to the vapour of the arc. Even when this is done, there is condensation at this surface and loss of pressure. When finding the density, the errors in the measurement of the temperatures counterbalance somewhat those made in the measurement of the pressure, for the measurements of both of these quantities will be too small and the density is directly proportional to one and inversely proportional to the other.

The apparatus employed is described in detail. The temperatures recorded are much higher than those given by Wills or Knipp. With a tube 3·8 cm. in diam. and a current of 3 amps. Wills gives the temperature as 145° C., when the electric force is 0·676 volts/cm. With the tube somewhat smaller and the same current and the same electric force the temperature here given is 640° C. Judging from the data given by Wills on the temperature in different sizes of tubes, the difference between the two tubes compared would account for but a few degrees. The temperatures given by Knipp are somewhat higher than those of Wills, but not nearly as high as those here given. On the other hand, these values are approximately the same as those given by Küch and Retschinsky for the mercury arc in a quartz tube.

The general conclusions arrived at are that the electric force in the mercury arc increases as the density of the vapour increases. It is approximately a linear function of the density of the vapour, but does not become zero when the density is zero. The electric force decreases about 8 % when the current increases from 3 to 7 amps. It has been suggested by Millikan that mercury molecules may be ionised by radiation which is produced by the impact between electrons and molecules, even when such impacts are not sufficiently violent to ionise directly. It is impossible at the present to offer a satisfactory explanation of the results obtained. A. E. G.

**75.** *Effects of Dielectrics on the Sparking Voltage.* **E. R. Wolcott.** (Phys. Rev. 12. pp. 284–292, Oct., 1918.)—The voltage required to produce sparking between two electrodes is materially reduced by the presence of a dielectric near one of the electrodes, under certain conditions [see Abs. 1098 (1901)]. The phenomenon is of considerable importance in the electrical precipitation of dust and fumes from gases, because the p.d. that can be maintained between the electrodes is thereby reduced, which, in turn decreases the efficiency of the operation. The electrical precipitation of dust and fumes from gases is accomplished by passing such gases through an electrical field formed between two electrodes, one being of small area, such as a wire, which is called the discharge electrode, and the other being of a relatively large area, such as a pipe concentric with the wire or a plate parallel to the wire, which is called the collecting electrode.

The discharge electrode is maintained at a high potential and the collecting electrode is earthed, the field between the two being uni-directional. The dust or fumes are repelled by the discharge electrode and precipitated upon the collecting electrode. That these deposits lower the efficiency of the operation was not recognised in the early stages of electrical precipitation, and consequently some of the results then obtained seemed quite anomalous. The following conclusions, arrived at as the result of experiments here described, apply only to distances between the point and plate which are comparatively large; *i.e.* over 8 cm. (1) The sparking voltage (peak) between a point and plate when the point is positive, is about half of that when the point is negative. (2) A dielectric of discontinuous surface placed over a plate in a point-to-plate uni-directional discharge lowers the sparking voltage, when the point is negative, to a value comparable to that when the point is positive. (3) The discontinuity of surface may be an edge or hole, or the body may be fibrous or porous. (4) No lowering of the sparking voltage results when means are provided for conducting away the charge, as when the deposit is sufficiently moist or is in a humid atmosphere. (5) No lowering of the sparking voltage results when means are provided for preventing the accumulation of a heavy charge, as by covering the dielectric with an earthed screen. (6) An intense brush glow appears upon the dielectric when just under the sparking voltage. The decrease in resistance of the gaseous medium between the electrodes thus produced is probably the cause of the lowering of the sparking voltage. Some experiments have also been tried using gases other than air, but these have not as yet been completed. A. E. G.

**76.** *Figures produced on Photographic Plates by Electric Discharges.* **U. Yoshida.** (Kyoto Coll. Sci., Mem. 2. pp. 315–319, Oct., 1917.)—A continuation of previous work [see Abs. 1007 (1917)]. Some peculiar effects obtained are illustrated, apparently due to spark light but not to any known form of photographic reversal: experiments are proceeding. A. D.

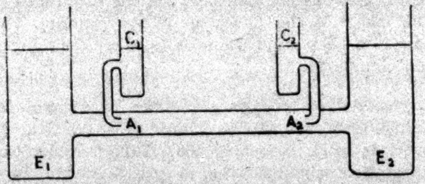
## ELECTRICAL PROPERTIES AND INSTRUMENTS.

**77.** *Variation of Electrical Resistance during Fusion.* **H. Tsutsumi.** (Tôhoku Univ., Sci. Reports, 7. pp. 93–105, Sept., 1918. Twentieth Report of the Alloys Research Inst.)—An experimental investigation of the variation of electrical resistance of the metals Hg, Sn, Bi, Pb, Zn, Sb, Al, Ag, and Cu as the temperature is gradually raised beyond the melting-point. Details of the experimental method employed and tables of results and curves are given in the paper. With the exception of Bi and Sb the resistance of all the metals increases considerably during fusion. There is probably a molecular transformation during the melting of Bi and Sb. The resistance-temperature curves in the solid state have but a slight upward curvature, except in the case of Bi and Sb. The curve for Bi rises with a steadily increasing rate, and similarly that for Sb up to 400° C., after which it bends downwards. The resistance-temperature curves for the liquid state are practically linear up to the max. temperature of observation. The following table shows the ratio of the resistivity in the liquid state $\sigma_l$ to that in the solid state $\sigma_s$. This ratio is compared with the quantity $WL/T_m$, where W is the atomic weight, L the latent heat of fusion, and $T_m$ the absolute temperature of the melting-point, although there is no apparent physical relation between the quantities.

| Metal. | Hg. | Sn. | Bi. | Pb. | Zn. | Sb. | Al. | Ag. | Cu. |
|---|---|---|---|---|---|---|---|---|---|
| $\sigma_l/\sigma_s$ | 3·22 | 2·03 | 0·43 | 2·07 | 2·09 | 0·67 | 1·64 | 1·74 | 2·04 |
| $WL/T_m$ | 2·35 | 3·30 | 4·78 | 2·02 | 2·65 | — | 2·31 | 1·94 | 2·03 |

The expressions for the specific electrical conductivity and the thermal conductivity of metals derived from the electron theory deviate considerably from actual facts, although the result for the ratio of the two conductivities is fairly well satisfied by some metals. To attain more concordant expressions it is supposed that in the solid state, in addition to the molecule vibrating about its mean position, there are dependent rotational vibrations of the molecules about their centres of mass, in virtue of thermal impacts. This reduces the mean free path of the free electrons and an expression for the resistivity is obtained proportional to the absolute temperature. The thermal conductivity, however, remains independent of T, and the slight increase observed may be due to partial transference of thermal energy by mutual molecular actions. The rotational vibration increases with the temperature and at fusion changes into a revolution, an abrupt increase of resistance arising. In the case of a cubic crystal the resistance in the liquid state would be approximately double that of the solid state. L. L.

**78.** *New Method for the Determination of Conductivity of Solutions.* **E. Newbery.** (Chem. Soc., J. Trans. 113. pp. 701–707, Sept., 1918.)—The author points out a number of objections to the usual method of determining the conductivity of solutions by the use of alternating currents, and suggests



a method by which the conductivity is determined, using a direct current. It is a simple modification of a common method for measuring the resistance of a metallic conductor by determining the fall of potential along it during the passage of a known current. The accompanying Fig. illustrates the method. A small but constant current is passed between the electrodes $E_1$, $E_2$, along the tube $A_1A_2$, and also through a standard resistance. Standard electrodes (calomel, mercurous sulphate, etc.) are constructed in the vessels $C_1$, $C_2$, and these are connected with an accurate dial potentiometer reading to five significant figures. The extremities of the standard resistance are also connected to the same potentiometer, and by means of a commutator, the fall of potential along the tube $A_1A_2$ and across the terminals of the standard resistance may be measured in rapid succession. The specific conductivity of the electrolyte is then given by $K = D^2/VR \times y/x$, where D is the distance between the electrode tips $A_1, A_2$; V is the volume of the liquid in the tube between the same points, R the standard resistance, and $x$ and $y$ the potential differences between the electrodes $C_1, C_2$, and between the terminals of the standard resistance respectively. A better form of apparatus is also described by the author, and the following values of specific conductance at 25° are given: N-KCl, 0·1124(7); NaCl (saturated at 25°), 0·2520(5); N-$AgNO_3$, 0·07796; N-$H_2SO_4$, 0·2187. A. F.

79. *Resistivity and Thermoelectric Power of Tungsten.* **H. Pécheux.** (Comptes Rendus, 167. pp. 487–489, Sept. 30, 1918.)—The author has measured the resistivity and thermoelectric power of three samples of drawn tungsten wire (diam. 0·1 to 0·485 mm.). The samples contained traces of iron; A, B, C [illegible]e in order of purity. Between 0° and 200° C. the resistivities are given by:—

$$\text{(A)}\ \rho_t = 5{\cdot}30(1 + 0{\cdot}0054t + 0{\cdot}0000195t^2)$$
$$\text{(B)}\ \rho_t = 5{\cdot}41(1 + 0{\cdot}0037t + 0{\cdot}0000041t^2)$$
$$\text{(C)}\ \rho_t = 5{\cdot}31(1 + 0{\cdot}0048t + 0{\cdot}0000015t^2)$$

The thermoelectric powers against Cu between 21° and 630° C. are represented by:—

$$\text{(A)}\ dE/dt = 0{\cdot}0336t - 0{\cdot}651$$
$$\text{(B)}\ dE/dt = 0{\cdot}0339t - 1{\cdot}120$$
$$\text{(C)}\ dE/dt = 0{\cdot}0358t - 1{\cdot}249$$

L. L

80. *Thermoelectric Action with Thermal Effusion in Metals.* **E. H. Hall** (Nat. Acad. Sci., Proc. 4, pp. 297–299, Oct., 1918.)—According to a previous paper [Abs. 868 (1918)] the e.m.f. of a thermo-couple was shown proportional to an area on the P-V plane whose boundary corresponded to the changes of pressure and volume undergone by 1 gm. of electrons, partly free and partly associated in traversing the circuit as part of the current. In the present note the author shows mathematically that this is not true if the free electrons in an unequally heated metal have a tendency like that which in ordinary gases produces the phenomenon of thermal effusion. The result only holds when the mechanical tendency is towards equality of pressure. L. L.

81. *Electrothermal Effect including the Thomson-effect as a Special Case.* **C. Benedicks.** (Comptes Rendus, 167. pp. 296–299, Aug. 19, 1918.)—The author has previously described experiments to show the existence of an electric current when there is a transport of heat in a homogeneous metal [Abs. 675, 1369 (1917)]. Experiments have now been carried out to show the reverse phenomenon, namely, "a transport of heat when a current traverses a conductor at constant temperature." If a current $i$ passes along a cylinder with a symmetrical constriction, the temperature difference $n$ between the sides of the constriction is given by $n = \mp k_1 i \pm k_3 i^3 \pm k_5 i^5$. The first term on the right is due to the new effect, the second and third terms contain the contribution due to the Thomson-effect and to the fact that the resistance increases with temperature. In the case of Pt experiment gives $n = 6{\cdot}01i - 0{\cdot}0833i^3 - 0{\cdot}00071i^5$.

The author regards the Thomson-effect as a special case of this new effect in that it relates to a conductor at variable temperature. L. L.

82. *Selenium Crystals under the Action of Vapours.* **W. E. Tisdale.** (Phys. Rev. 12. pp. 825–835, Oct., 1918.)—The response of hexagonal Se crystals to light may be altered by subjecting them during formation to saturation with gases (H, N, O, air, and Ar) or vapours (Hg, Sn, Bi, S, or As). The experiments described show that nitrogen gives the most sensitive preparations, and argon the least. Nitrogen also shifts the max. response towards the smaller wave-lengths (about 762 $\mu\mu$ with a half-watt lamp, against 805 $\mu\mu$ for air saturation). Metallic vapours produce a pure surface effect, the conducting surface layer producing an apparent conductivity which may be reduced by light. The author calculates recombination coefficients on the basis of Fournier d'Albe's ionisation theory of light action in Se. [See Abs. 209 (1914) and 902 (1915).] E. E. F.

83. *Sensitivity of the String Galvanometer.* **J. K. A. W. Salomonson.** (K. Akad. Amsterdam, Proc. 21. 1. and 2. pp. 235–242, 1918.)—In Einthoven's string galvanometer the deflection constant is proportional to the square of the periodic time and so depends on the tension as well as on the dimensions and material of the string and the strength of the magnetic field. The lower limit of tension is given by the condition of no load. The frequency of vibration is then represented by $N = (m^2 d / 8\pi l^2)(E/g)^{1/2}$, where N is the frequency, $l$ the length and $d$ the diam. of the string, $g$ the density, and E Young's modulus, $m = 4{\cdot}73$. A table is given showing for different materials the "material-factor," *i.e.* the deflection per microvolt with strings of 1 $\mu$ diam. and 10 cm. length. Gold fibres, if critically damped, will give a larger deflection than those of any other material of the same dimensions, but the time of vibration, and consequently the time of deflection, is larger than with other strings. For measurement with small potential differences Al is the best material. For the theory on which the calculations are based the original paper should be consulted. J. W. T. W.

## ALTERNATING CURRENTS AND MAGNETISM.

84. *Calculation of Magnetic and Electric Saturation Values.* **J. R. Ashworth.** (Phil. Mag. 36. pp. 351–360. Oct., 1918.)—The author calculates the limiting value ($I_0$) of the magnetic intensity for a substance obeying Curie's law. If the intensity of magnetisation I for field strength H is comparable with $I_0$, then $H(1/I - 1/I_0) = R'T$. R′ is the reciprocal of the Curie constant and T the absolute temperature. To change the magnetic energy from $HI_0$ to HI, where H is constant, thermal energy must be supplied which may be expressed in terms of the gas-constant R. From these premises the author deduces $I_0 = (R/R')^{1/2}$. Values calculated in the case of Fe, Ni, and Co compare favourably with the saturation values determined experimentally. Analogous reasoning is then applied to estimate the limiting current density ($i_0$) for a metal in which the resistivity ($\sigma$) is proportional to the absolute temperature. The author obtains $i_0 = (RvT/\sigma)^{1/2}$, where $v$ is the velocity of the electron as it passes along the conductor. Taking $v = 10^7$ cm./sec., $i_0$ is of the order $10^8$ amps. per cm.$^2$; the metals being assumed monatomic in the solid state. Traubenberg has recently shown that in the case of Ag, Ohm's law holds good up to $8 \times 10^6$ amps. per cm.$^2$. The theory of metallic conduction outlined by J. J. Thomson [Abs. 1085 (1915)] gives a result $\sqrt{(3)}$ times that obtained by the author. To account for super-conductivity it is only necessary to introduce the intrinsic field and proceed as when the gas law is made to include liquids by the introduction of an intrinsic pressure. The

magnitude of the intrinsic field can then be estimated. In the case of lead it would be less than 79 volts/cm. L. L.

85. *Kinetic Theory of Magnetism.* **K. Honda and J. Ôkubo.** (Tôhoku Univ., Sci. Reports, 7. pp. 141–166, Sept., 1918. Twenty-second report of the Alloys Research Inst.)—During the last two years the authors have published papers in which Ewing's theory of molecular magnetism has been treated quantitatively and the chief facts of ferromagnetism explained. The theories of Weiss and Langevin relative to para- and diamagnetism require modification to account for some observed phenomena. According to Langevin the diamagnetic susceptibility of the elements should increase with their atomic weight. The susceptibility, however, varies periodically with the atomic weight. This can be reconciled if the diamagnetism observed be regarded as a differential effect of para- and diamagnetic phenomena. Weiss explains ferromagnetism by the introduction of a large molecular field, but the thermomagnetic properties accounted for can be equally well explained by other theories, and there are difficulties in the conception of such an internal field. Langevin, in his paramagnetic theory, treats the magnetic molecules similarly to the gas molecules in the kinetic theory of gases. When an external field is applied the magnetic axes tend to set in the direction of the field, but this is opposed by thermal impacts.

According to the authors the matter is more complex than Langevin assumes. Generally, the axis of rotation of a molecule does not coincide with the magnetic axis. The moment should be resolved along and normal to the axis of rotation (axial and transverse components). The application of a field will give rise to precession and nutation of the axis of rotation round the direction of the field in virtue of the axial component of the moment. This is dealt with mathematically for a field applied suddenly and one of gradual application, and a paramagnetic effect is established increasing with the field as in the Langevin theory. The transverse component of the moment, which rotates continuously with the molecule, is shown to produce a diamagnetic effect. The total effect may be either para- or diamagnetic, according to which of these predominates. The shape of the molecule is the determining factor and not its magnetic moment. In the case of a spherical molecule the resultant effect would be paramagnetic. Assuming that the molecular magnets consist of electrons revolving about positive nuclei, and that this revolution is not affected by variation of temperature, it is shown that Curie's law for a paramagnetic gas is obeyed and that under certain conditions the diamagnetic susceptibility is independent of the temperature. An additive diamagnetic term is necessary to the theory, owing to the fact that the molecular magnets are not necessarily rigid, the motion of the electrons being slightly modified by a strong field. The theory is applied to the calculation of the moment of the H atom ($2{\cdot}95 \times 10^{-21}$), and if the Bohr model be assumed the H molecule would be paramagnetic. To be diamagnetic the positive nuclei must approach very near to each other—a distance less than 1/50th of the radius of the electron orbits.

Solids are then considered, the molecules being arranged in a space lattice and making rectilinear oscillations but not rotations. The change in the susceptibility of Sn from para- to diamagnetic at fusion is explained.

The theory is then extended to ferromagnetic substances. In this case the gyrostatic action of the molecules is small in comparison with the mutual magnetic action, the latter being the predominating factor in explaining observed facts. To account for the effect of temperature on magnetisation, the molecules of a ferromagnetic substance are supposed to rotate continuously about their magnetic axes and at the same time to execute small vibrations in a direction at right angles. The first motion explains the diminution of magnetisation with temperature, while the second accounts for the increase in weak fields. At ordinary temperature the energy of the axial rotation is very small, but increases rapidly with rise of temperature. The development of the theory gives the calculated critical temperature of iron as 790° C., and the theoretical I–T curve similar to that observed in strong fields. The transformation point ($A_2$) is not to be regarded as an allotropic change, but as a process of acquiring rotational energy of the molecules, the amount being a definite function of the temperature. The susceptibility of a ferromagnetic substance above the critical point follows the same law as that deduced by Weiss in his molecular-field theory. L. L.

**86.** *The Reversal of the Corbino-effect in Iron.* **A. W. Smith.** (Phys. Rev. 11. pp. 337–339, Nov., 1918.)—Chapman has observed that the Corbino-effect in iron reverses sign with low magnetic fields (250 gauss) [Abs. 1290 (1916)]. If this effect is directly related to the Hall-effect then a reversal of the latter is probable in low fields. With this in view the author has measured both effects in an iron plate, using fields up to 600 gauss. While the Corbino-effect changes sign and is not simply related to the field strength, the Hall-effect shows no such reversal and is approximately proportional to the field. L. L.

**87.** *The Relation between certain Galvanomagnetic Phenomena.* **C. W. Heaps.** (Phys. Rev. 11. pp. 340–350, Nov., 1918.)—The author discusses the relation between the Hall and Corbino effects and the change of electrical resistance in the magnetic field from the point of view of the electron theory. It is shown that the Hall coefficient $R = -3/2ne$, where $e$ is the electronic change and $n$ the number of free electrons in unit volume. The Corbino constant $E = (e/m)T$, where T is the mean free time of the electron. Since the two effects yield information about two different concepts in the theory of metallic conduction, namely $n$ and T, it is not to be expected that there will always be correspondence between the two coefficients. The case of a rectangular plate, placed between the poles of an electromagnet and which may be traversed by mutually perpendicular currents from separate batteries, is then considered and the relation $E = (e/m)T = R/\rho$ established, where $\rho$ is the specific resistance of the material. Experimental investigations on Cu, Zn, Bi and natural graphite crystals were carried out on plates of this form, the arrangement being such that all three phenomena could be measured. In Zn and Cu the Corbino constant is apparently independent of the magnetic field. In Bi the three effects behave in the usual manner, but in crystalline graphite the resistance increases rapidly with the field, the Corbino constant decreases and the Hall constant increases. Both the free period and the number of free electrons per unit volume are affected by placing the metal in the magnetic field. L. L.

**88.** *Coefficients of Magnetisation of Oxygen and of Nitric Oxide, and the Theory of the Magneton.* **E. Bauer, P. Weiss, and A. Piccard.** (Comptes Rendus, 167. pp. 484–487, Sept. 30, 1918.)—The authors have taken up again the determination of the coefficients of oxygen and of nitric oxide [Abs. 562 (1914)]. The principle of the method previously employed was to measure the difference of level in a magnetic field, of water, in one case in an atmosphere of hydrogen and in the other in an atmosphere of the gas to be studied. Formerly U-tubes were employed, but it has been found that it is necessary to work in closed tubes, as otherwise considerable errors are introduced. The coefficients of magnetisation of oxygen and nitric oxide at 20° have been found to lie between the limits $1{\cdot}0695 \times 10^{-4}$ and $1{\cdot}0790 \times 10^{-4}$ in the case of oxygen, and $0{\cdot}483 \times 10^{-4}$ in the case of nitric oxide.

Measurements have also been carried out by another method. A horizontal column of a paramagnetic gas ends, on the one hand, in the atmosphere, while the other end is in a magnetic field H. One measures directly the excess $\frac{1}{2}KH^2$ of the pressure in the field over the external pressure, with the help of a small water manometer. By means of this method definite values have been obtained for the coefficients of magnetisation ($\chi$) and for the magnetic moment per gm. molecule or gm. atom ($\sigma$) calculated by the formula of Langevin:—

For oxygen:

$$\chi_{20^\circ} = 1{\cdot}077 \times 10^{-4} \pm 0{\cdot}008 \times 10^{-4}; \quad \sigma_{O_2} = 1{\cdot}587 \times 10^4; \quad \sigma_O = 0{\cdot}793 \times 10^4.$$

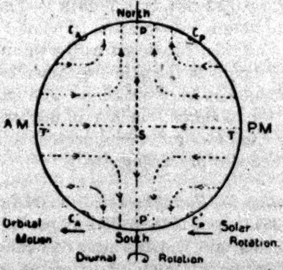
For nitric oxide:

$$\chi_{20^\circ} = 0{\cdot}487 \times 10^{-4} \pm 0{\cdot}0025 \times 10^{-4}; \quad \sigma_{NO} = 1{\cdot}033 \times 10^4.$$

On dividing by the gm. magneton, 1123·5, we obtain $n = 7{\cdot}06$ per gm. atom of oxygen and $n = 9{\cdot}20$ per gm. molecule of nitric oxide, two numbers which are not integers. These numbers, calculated in the usual manner, are not in harmony with the theory of the magneton. This, however, rests on such a body of concordant observations that it cannot be given up. The authors suggest, therefore, either oxygen and nitric oxide are exceptions to the general law or the observed discordances are due to a deviation of the classical kinetic theory from the facts. Such deviations are frequent, and the authors recall the facts which rendered the quantum hypothesis necessary, and the unexpected forms found by one of them for the characteristic equation of liquids.

A. F.

89. *Outline of a Theory of Magnetic Storms.* **S. Chapman.** (Roy. Soc., Proc. 95. pp. 61–83, Oct. 7, 1918.)—The changes in the magnetic elements which occur during a storm may be separated into two parts. The first (*a*) is dependent upon storm time, *i.e.* the changes follow an ordered sequence from the time of commencement of the storm simultaneously in all parts of the earth. This is termed the "General storm variation." The second (*b*) consists of a diurnal variation which depends on local solar time and is not therefore simultaneous at different stations. The excess of this diurnal change above the normal diurnal variation for the time of year at the station is termed the "Local storm variation." There are in addition irregular short-period



fluctuations. The normal types for (*a*) and (*b*) are worked out for different stations from 40 storms, and the features described and illustrated. In the next part of the paper systems of electric currents in the upper atmosphere which would account for the observed features are described. The general storm variation (*a*) can be accounted for by a flow approximately orthogonal to the magnetic meridians, first from west to east and afterwards of greater intensity from east to west. The local storm variation (*b*) may be explained by a current system as shown on the diagram, where S is the earth point which has the sun in the zenith. The earth rotates beneath this system and the effects thus depend upon local time. The last part of the paper, which is more speculative, describes how these current-systems may be set up by an influx of charged particles from the sun. A more detailed mathematical discussion of the whole subject is promised later. J. S. Di.

## RADIOGRAPHY AND ELECTROPHYSIOLOGY.

90. *Anthropometric Radiography of the Thumb.* **H. Béclère.** (Comptes Rendus, 167. pp. 499–500, Sept, 30, 1918.)—The method described makes it possible to obtain radiographs on which there are superposed details of the skin structure upon the image of the skeleton. In the case of the fingers the image of the nail also is given. To obtain these details it is necessary to powder the part under investigation with a salt of very high atomic weight; experimental hints are given when minium is the salt used. In order to obtain consistent results, the new Coolidge tube is employed and rays of hardness 5° to 6° Benoist, obtained by means of a Gallot transformer, are found to give the most satisfactory results. Ordinary radiographic plates are used, the antikathodic distance being 40 cm., and with a current of 10 milliamps. the time of exposure allowed is 8 secs. The clearness of the images obtained is such that it is possible to use them for the production of enlargements of considerable size. [See also next Abs.] A. E. G.

91. *A Help in the Production of Stereoscopic Radiographs.* **H. Béclère.** (Comptes Rendus, 167. pp. 533–534, Oct. 7, 1918.)—That portion of the limb of which it is desired to obtain radiographs is coated with a very thin layer of vaseline or lanoline and then powdered with a salt opaque to X-rays. By this means the smallest details of the skin are shown up on the plate and the stereoscopic effect obtained is very striking. The skin is seen as a flimsy envelope surrounding the skeleton, but not in any way detracting from the clearness of its image. Any foreign bodies present in the limb are easily and accurately located. [See also preceding Abs.] A. E. G.

92. *Units of Quantity in Radiotherapy.* **T. Nogier.** (Archives d'Él. Médicale, 26. pp. 356–361, Sept., 1918.)—This paper is a plea for the adoption by the Allies of the Bordier unit I, which may be defined as "the quantity of X-rays capable of setting free 0·1 mgm. of iodine in 1 cm.$^3$ of a solution of iodoform in chloroform (2 % solution) under a thickness of 1 cm., with normal incidence, and shielded from the light" [see Abs. 1196 (1918)]. The dose which produces slight erythema is 4 units when no filter is used. The other units such as that of Holzknecht (H), the Zimmern or Villard unit (V), the Ledoux-Lebard or Sabouraud-Noiré lines (S.N.), the Kienböck unit (X), the Schwarz unit (Kalom or K.), and the Guilleminot unit (M) are discussed and their deficiencies pointed out. A. E. G.

## CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

93. *Preparation and Properties of Yttrium Mixed Metal.* **J. F. G. Hicks.** (Am. Chem. Soc., J. 40. pp. 1619–1626, Nov., 1918.)—The present communication is a preliminary study of the conditions necessary to produce "yttrium mixed metal" analogous to "cerium mixed metal." The method of preparing anhydrous chlorides of the yttrium earths by dehydration in an atmosphere of dry hydrogen chloride at 350–400°, has been worked on a large scale. Yttrium mixed metal has been prepared in powder form by decomposing the anhydrous chlorides with sodium *in vacuo*, and by the electrolysis of these chlorides in the fused condition. Electrolysis of a solution of the oxides of the yttrium-earth metals in fused cryolite has been found less efficient than other methods. In the electrolysis of the chlorides, metal fog was very noticeable and there was a loss of chloride by volatilisation when open cells were used.

Yttrium mixed metal has been obtained in coherent form for the first time by sintering the metal powder *in vacuo*. The resulting mass tends to disintegrate while metallographic specimens are being prepared from it, and on exposure to the air. The sintered metal was bluish-grey in colour, not of a very high lustre, although capable of taking a good polish. It soon tarnished in contact with the air. A sample containing 0·32 % of carbon had $d^{15}_{15} = 5{\cdot}508$. It burns at a rather low temperature in the air, with a bright flash, like magnesium, leaving a residue of light-brown oxide. The powdered metal glows when heated in an atmosphere of hydrogen, nitrogen, or $CO_2$, CO being evolved in the last-mentioned case. A. F.

94. *Effects of Heat on Chemical Glassware.* **R. G. Sherwood.** (Am. Chem. Soc., J. 40. pp. 1645–1653, Nov., 1918.)—When glass is heated two distinct kinds of gaseous evolution take place: that resulting from adsorbed products which are readily removable at temperatures below 300°, and that resulting, in all probability, from a chemical decomposition of the glass itself. The latter effect becomes important above 400° for the softer glasses tested, and above 500° for the harder glass. There is some evidence of a definite characteristic rate of gaseous evolution for each temperature to which the glass is subjected, increasing with the temperature and extending over a considerable period. Observations on one sample at 500° showed a small continuous evolution even after 20 hours of heating. Adsorption products are confined to quantities which are represented approximately by a layer of gas about one molecule deep and are removed with much greater rapidity at lower temperatures than the other products obtained due to the heating of the glass. The most important of the gaseous evolution products obtained from glass under the influence of heat is water, which, as the temperature is raised to the softening point of the glass, constitutes almost the entire quantity of the evolution, but which at a lower temperature may be relatively unimportant. A. F.

95. *Platinum and Illuminating Gas.* **F. Mylius** and **C. Hüttner.** (Zeits. Anorg. Chem. 95. pp. 257–283, 1916.)—Of two platinum muffles, both much of the same composition, the one had kept in a good state, whilst the other was badly corroded, apparently owing to the character of the gas. Experiments were, therefore, made in the Reichsanstalt both with these

platinums and with very pure Pt, and with ordinary coal gas and with a synthetic gas (methane, ethylene, CO, H). Heated in a luminous flame the Pt turns black; in the Bunsen burner the black disappears again, but the metal surface is roughened and the repeated sooting of Pt leads to an appreciable loss of weight. Coal gas acts on technical Pt already at 600° C.; synthetic gas does not attack pure Pt or Pt-Ir at this temperature, but blackens ordinary platinum. The soot deposit and corrosion are favoured by the presence of iron and rhodium; palladium, and especially iridium, are much less injurious. In coal gas the chief detrimental impurity is $CS_2$ which forms a sulphide with Pt that is decomposed again at high temperature; even iridium causes, in the presence of $CS_2$, the deposition of much soot; rhodium takes up sulphur from $CS_2$ and $SO_2$ already at 100°. To prevent platinum losses a pure gas free of sulphur and an ample air supply should be secured. H. B.

96. *Occlusion of Hydrogen and Oxygen by Metal Electrodes (Palladium).* **E. A. Harding** and **D. P. Smith.** (Am. Chem. Soc., J. 40. pp. 1508–1531, Oct., 1918.)—A continuation of the experiments by Smith and Martin [Abs. 275 (1917)]. The Pd wire was so suspended in the electrolytic cell (glass) that the changes in length could be observed by a telescope while determining the resistance by the aid of a Kelvin double bridge. In order to ensure constant resistivity, the wires were annealed in a nitrogen atmosphere; this annealing of Pd charged with hydrogen and the electrolytic treatment have no permanent effect on the resistance; the annealing has to be carried out with great care, however, as the hydrogen is suddenly given off near 300° C., and the wire weakened thereby. The resistance curve of a series of tests lasting about 1200 minutes consists of 4 branches. In the first, the changing period, the resistance rises to a certain height to fall off again; when in the second period the hydrogen is allowed to escape spontaneously, the resistance rises again, higher than before, and falls once more; a similar curve is obtained in the third period, when the electrode is again made to occlude hydrogen; in the fourth period all the hydrogen is expelled by reversing the current, and the resistance falls lower than previously, to its original value. The current interruptions were effected by a switch or a rotating commutator. Experiments were also made with anodically polarised electrodes. The experiments confirm Martin's suggestion that in charging Pd with hydrogen there is first a transitional period in which the resistance falls because the ionic hydrogen accumulating helps to conduct. This first stage passes, especially with currents of high density, soon into the second stage, during which the hydrogen is alloyed with the Pd, and the resistance increases. With oxygen occlusion the first stage and the resistance-fall are very rapid. There is not much said about the experiments with other metals. Tungsten and iron behaved like Pd; Pt showed a very slow resistance-fall and a slow recovery on interrupting the current. The transitional form of hydrogen seems in Pd to be chiefly responsible for the changes in length, which alone would not account for the resistance-changes; the alloy form is more persistent. H. B.

97. *Internal Stresses developed in Metals and Alloys by Rapid Cooling.* **Portevin.** (Comptes Rendus, 167. pp. 531–533, Oct. 7, 1918.)—By using the method of Heyn and Bauer (Int. Zeits. Metallog., 1911, I. pp. 16–48) the internal longitudinal stresses present in quenched samples of several metals and alloys have been measured. For copper quenched in water from 750° C.

these are negligibly small; for nickel they vary between −10 and +6 kg./mm.$^2$, while for a brass containing 60 % of Cu they exceed ±15kg./mm.$^2$. Tempering after the hardening, designed to minimise the internal stresses set up by the hardening, may, if it is followed by rapid cooling, set up fresh stresses, as is illustrated by the measurements on the two following steels quenched in water from 850° C. in the form of cylinders of 70 mm. diameter.

(1) A medium hard steel—

| | | Peripheral Compression in kg./mm.$^2$. |
|---|---|---|
| Reheated to 550° C. followed by ......... | slow cooling............... | −4 |
| | quenching in water...... | −14 |
| Reheated to 700° C. followed by ......... | slow cooling............... | −0·1 |
| | quenching in water...... | −27 |

(2) Nickel-chromium steel (C, 0·3; Ni, 2·5; Cr, 0·7)—

| | | Peripheral Compression. Kg./mm.$^2$. | Central Extension. Kg./mm.$^2$. |
|---|---|---|---|
| Reheated to 500° C. followed by ......... | cooling in air ......... | −3 | +15 |
| | „ in water ... | −11 | +31 |
| Reheated to 670° C. followed by ......... | cooling in air ......... | −4 | +10·5 |
| | „ in water ... | −34·5 | +49·5 |

F. C. T.

**98.** *Influence of Silicon and the Decarburisation Period on Malleable Cast Iron.* **E. Leuenberger.** (Stahl u. Eisen, 37. pp. 513–521, May 31, and pp. 601–610, June 28, 1917. Rev. de Mét. 15E. pp. 294–303, Sept.–Oct., 1918. Abstract.)—Preliminary experiments with an iron of 0·57 % Si, 0·25 Mn, 0·085 P, 0·25 S showed the unreliability of conclusions drawn from a few tensile tests of specimens cut from malleable castings. Rods 23 mm. in diam. were cut, heated for 150 hours and then turned to diameters of 20, 17, 14, 11 mm.; the elongation decreased from 6 to 1 % with the diameter; the tensile strength remained first unchanged, but dropped suddenly from 32·5 kg./mm.$^2$ to 24·6 kg., as the diam. was reduced from 14 to 11 mm. Ordinary determinations differ much owing to the irregular distribution of the carbon. In the investigation 17 charges each of 600 kg. were fused in an oil furnace and ferro-silicon was added so as to obtain materials ranging in Si from 0·17 up to 1·08 %; lower Si metal was porous, with higher Si graphite segregation set in. Forty rods were prepared for each of the several series of tests; they were cast in iron moulds and slowly cooled in them, then sand-blasted and heated with hammer-scale—not all fresh, lest the oxidation be too energetic—in decarburising furnaces for periods of 95, 130, 175, 225, 260 hours total up to 980° C., this temperature being reached in 12 hours. The cooling took 32 hours. All the tests were conducted on technical lines. The loss of carbon amounted to 84 % after the first, and to 96 % after the fifth heating; the temper-carbon and the total carbon curves ran parallel; the carbon loss decreased as the Si increased to 0·65 %, and then increased again. The other elements were hardly affected by the heating. The tensile strength decreased with prolonged heating, the elongation (2 to 19 %) and contraction of area increased; the Si-content does not affect the tensile strength, but lowers the other values, especially with long heating. The values of the notched-bar impact tests were only influenced by prolonged heating with low-silicon iron, which then gave a higher impact strength. The Brinell hardness decreased with long heating; the specific gravity decreased with long heating and with increasing Si percentage; as regards volume, there was contraction in the specimens containing less than 0·55 % Si, and expansion in the specimens of higher Si-content, the changes becoming more marked with prolonged heating. Resistance tests were made with the aid of a Kelvin double bridge, the arrangement eliminating the contact resistances; the rods were polished. The resistance increased in the untreated specimens from 42 to 68 microhms-cm. as the silicon percentage was raised from 0·23 to 1·08, this being a cementite resistance; in the decarburised material the resistance was much lower, and the respective resistance values were 19 to 34 after the first heating and 16·5 to 32·5 after the fifth heating, this being a ferrite resistance. For the rust tests short turned cylindrical rods were horizontally suspended for 20 days in flowing water. The Si percentage had no distinct influence on the rather irregular corrosion. H. B.

99. *Chemical Detection of Strain in Iron and Steel by their Reaction with Nitric Acid.* **J. H. Whiteley** and **A. F. Hallimond.** (Iron and Steel Inst., Carnegie Schol. Mem. 9. pp. 1–58, 1918.)—The final reduction products obtained when iron is dissolved in dilute nitric acid are chiefly $NO_2$, NO, N, and $NH_3$. A method is described for collecting and analysing these gases, the amounts being formed depending on the strength of acid and the degree of cold work in the sample. At an acid strength of 24 gm. per 100 $cm.^3$ an abrupt change in the reaction occurs, the N and $NH_3$ which are the chief products with weaker acids, being replaced by NO and $NO_2$. By plotting the weight of iron consumed in forming N and $NH_3$ against the acid strength a characteristic "reaction-curve" is obtained. This curve is shifted by cold work in the sample of iron, and hence affords a ready means of determining whether a given sample is strained or not. Annealing a strained sample at 520° C. causes a reversion of the curve to the normal. F. C. T.

100. *Carbide Formation and Stability.* **O. Ruff.** (Zeits. Electrochem. 24. pp. 157–162, June 1, 1918. Paper read before the Deut. Bunsen-Gesell. Engineering, 106. p. 531, Nov. 8, 1918. Abstract.)—Owing to the retention of gases by carbon it is hardly possible to maintain a vacuum of 5 mm. of mercury in a carbon furnace first filled with ordinary gases, N, H, CO; compounds are formed and decomposed again so that carbon is transferred from spots of high temperature to parts of lower temperature. To avoid this the author works in an argon atmosphere. The paper refers in particular to the carbides of Al and Cr as typical. Liquid Al dissolves little carbon, but the solid $Al_4C_3$ is easily formed. This carbide is not fusible at ordinary pressure, but sublimes when free of N, near 2200° with partial decomposition; at 400 mm. it decomposes into graphite and aluminium; the vapours are richer in carbon at higher than at lower temperatures. Chromium dissolves carbon readily when fused and forms fusible carbides which evaporate under decomposition. At 2270° Cr saturated with carbon boils, the vapour consisting entirely of Cr; between 2050° and 2250° the melt corresponds to $Cr_3C_2$; when the temperature is lowered, graphite and this carbide coexist down to 1875°. The reactions with carbon of different metallic oxides in atmospheres of H, N, CO depend mainly upon the fusibility of the oxides and their capability of dissolving carbon. All the carbides seem to be decomposed at high temperatures, the more readily the more positive these metals are; there are many carbides, corresponding in their formulæ to $CH_4$, $C_2H_6$, $C_2H_4$, $C_2H_2$, $C_4H_{10}$, etc. The heavy metals seem to possess lower valencies in their carbides than in other

compounds; tungsten yields WC, $W_2C$, $W_3C$; the low-carbon compounds, $Mn_3C$, $Cr_3C_2$, $W_2C$ seem to be stable at all temperatures with respect to the solid and liquid metal. H. B.

101. *Glass Annealing.* **S. English and W. E. S. Turner.** (Soc. Glass. Technol., J. 2. pp. 90–102, June, 1918. Engineering, 106. pp. 148–149, Aug. 9, 1918. Abstract.)—Glass can rapidly be annealed at the "upper," and slowly at the "lower" temperature. In their polarisation apparatus, the authors heat glass cylinders, 8 cm. in length, in a tubular electric furnace, and wait either for the clearing of the field of the coloured rings or for the complete darkening of the field; in both cases a difference in temperature of a few degrees may make a large difference in the time required for annealing, *e.g.* 4·5 hours, 18 minutes, 10 minutes at 600°, 625°, 630° respectively. To study the softening of glass during rapid annealing a glass rod is fixed at one end while heated in the horizontal furnace; or a long rod is supported midway on a brick while in the annealing oven, and the bending (deflection of the ends) is measured. The rate of cooling should neither be uniform nor first accelerated and then slowed down or *vice versa.* Just below the upper annealing temperature the glass may be cooled rapidly, at the rate of 25 deg. C. per hour, *e.g.* from 585° down to 500° C.; then between 500° and 400° even a slow rate of 9 deg. per hour may set up strains; in the cooling-off stage, when the glass has stiffened, the rate may be raised again. Thus ovens should be constructed for 3 rates of cooling, which may technically be very difficult if several varieties of glass are simultaneously to be treated. The chemical composition is very important for this rate of cooling; boric acid glass, and still more chemical glassware proved particularly sensitive, especially in the second slow period. The experiments were made in the department of Glass Technology, Sheffield University. H. B.

102. *Conductivity of Soda-Lime-Silicate Glasses.* **R. Ambronn.** (Phys. Zeits. 19. pp. 401–405, Sept. 15, 1918.)—In continuation of former experiments [Dissertation, Göttingen, 1918; Abs. 1043 (1918)], the author examines 18 glasses containing only silica, soda (12 to 36 % $Na_2O$), lime (4 to 20 % CaO) and possibly a little arsenic. The glass with 26 $Na_2O$ and 16 CaO did not weather well. Cylinders (30 or 15 mm. high, 11 or 16 mm. diam.) were tested at 10 different temperatures (100 to 450° C.) by direct current of low voltage (0·01 to 10) converted to alternating at 10 to 100 periods by a rotating commutator; 8 determinations at varying frequency and potential were made at each temperature. The actual conductivities observed are not stated, but the paper gives the constant for the empirical formula $L = L_0 e^{-B/\theta}$, where $L_0$ is the conductivity at absolute zero and is determined by $L_0 = M + \mu c + \nu k$, $c$ being the concentration of $Na_2O$, while $k$ is the CaO concentration. B decreases with increasing $c$ and increases with increasing $k$ and is determined by $B = \alpha ck + \beta c + \gamma k + \delta$. It is found that the conductivity assumes positive values only when $c$ exceeds 28 % or $k$ 28·5 %. It is concluded that not all the silicates in glasses are capable of dissociation, and that of 100 atoms of the substance 11 atoms of Na and Ca jointly are fixed and do not participate in carrying the current. H. B.

103. *Fluidity.* I. **C. Drucker.** (Zeits. Phys. Chem. 92. pp. 287–319, June 19, 1917.)—The author points out the necessity for distinguishing between static properties of bodies, which can be determined while a transformation of energy does not take place during the measurement (vapour

pressure, surface tension, expansion), and dynamic properties (conductivity, permeability, fluidity) which can only be determined while energy flows through the body. In discussing in particular viscosity of gases and gaseous mixtures, viscosity and vapour pressure, fluidity of liquid mixtures, fluidity and heat of fusion, he starts from the assumption that we cannot ascribe to liquids the molecular weights of the vapours (in the form of ideal gases), because liquids are mixtures of complexes. The data are taken from various experimenters. The viscosity of gases and liquids is closely related to surface phenomena, and the fluidity of liquids at different temperatures is an almost linear function of the vapour pressure. Even in the presence of a chemical combination between two liquids, the fluidity of the binary mixture corresponds to a linear mixture formula, or at any rate to a formula of a higher degree, unless the complex condition be sensitive to the volume change induced by the movement, when a mixture formula cannot be given. The heat change can be calculated from the temperature-coefficient of the fluidity, and is often identical with the heat of fusion. The heat change of the spacial orientation of the crystals represents, as a rule, only a very small fraction of the heat of solidification; this accounts for the great influence upon the crystal structure, of impurities which could not materially affect the heat of fusion. H. B.

104. *The Abnormality of Strong Electrolytes.* III. *The Osmotic Pressure of Salt Solutions and Equilibrium between Electrolytes.* **J. C. Ghosh.** (Chem. Soc. J., Trans. 113. pp. 707–715, Sept., 1918.)—A continuation of previous work [Abs. 881 (1918)], in which the author assumes that a salt solution is always completely ionised, the force of attraction between ions being governed by the law of inverse squares; and further, that the arrangement of ions in a univalent binary electrolyte corresponds with a simple cubic lattice, while in a solution of a ternary electrolyte the arrangement corresponds with a fluorspar lattice. The author derives the following equations: $A=2RT\log_e(\mu_{\infty}/\mu_v)$ for universal binary salts; $A=8RT\log_e(\mu_{\infty}/\mu_v)$ for ternary salts; and $i=n\left\{1-\frac{1}{3}\log_e(\mu_{\infty}/\mu_v)\right\}$. The validity of these fundamental equations has in the author's opinion been completely demonstrated both in aqueous and non-aqueous solutions. The variation of the activity-coefficient with temperature has been successfully calculated, and the conditions for isohydry have been determined. In fact, the author holds, a complete theory of dilute salt solutions has been propounded. A. F.

105. *Physical and Chemical Data of Nitrogen Compounds. Specially compiled for Use in Conjunction with the Synthesis and Oxidation of Ammonia.* (Engineering, 126. p. 620, Nov. 29, 1918. Munitions Inventions Department. Research Laborat. University College, London.)—This is the first of a series of publications to be issued by the above department and deals with gas data (PV relations, van der Waals' constants and critical data, density, viscosity, latent and specific heat, and thermal conductivity), nitric acid data (velocity of oxidation of nitric oxide by atmospheric oxygen, etc.), hydrogen purification (water gas equilibrium and the equilibria of the allied reactions between carbon and carbon oxides, oxygen, hydrogen and iron oxide and methane). A section on miscellaneous data (heats of formation, of fusion and modification, latent heats, etc., and conversion tables) is also added. The publication is a valuable one for all interested in the synthesis and oxidation of ammonia and in the production of hydrogen. A. F.

**106.** *The Variability with Time of the Distributions of Emulsion Particles.* **L. S. Ornstein.** (K. Akad. Amsterdam, Proc. 21. 1 and 2. pp. 92–95, 1918.)—M. v. Smoluchowski has previously discussed this problem [see Abs. 188 (1916), 858 (1917)] and deduced a formula for the average change of the number of particles in an element, which at the moment zero contains *n* particles, namely: $\overline{\Delta}_n = (\nu - n)\mathrm{P}$, where P is the probability that a particle which lies in the element at the time zero may have come outside in the moment *t*, whilst $\nu$ is the number of particles which at a homogeneous distribution over the whole volume would come to lie in the element in consideration. Also for the average square with a given number of particles *n* at the time zero Smoluchowski gives the formula: $\overline{\Delta^2}_n = [(n - \nu)^2 + n]\mathrm{P}^2 + (n + \nu)\mathrm{P}$, from which follows, if the average also is determined according to *n*, $\overline{\Delta^2} = 2\nu\mathrm{P}$. These relations are deduced by v. Smoluchowski with the help of the calculus of probability, and after the summation of very complex series. The author now demonstrates the above simple result by a less complicated method, and then extends the given formulæ to the case where the deviations of density in the various elements of volume are not independent, but where concerning the emission of particles independence of the events has still to be assumed. The considerations advanced may also be applied, at least approximately, to the changes which accidental deviations in density undergo during diffusion. The formulæ then show that close to a critical point the deviations in density as a result of their correlation are not only stronger on the average, but also more strongly changeable. H. H. Ho.

**107.** *Planck's Formula for the Potential Difference between Solutions and the Values of certain Important Cells.* **H. A. Fales** and **W. C. Vosburgh.** (Am. Chem. Soc., J. 40. pp. 1291–1316, Sept., 1918.)—Planck's formula for the contact p.d. between solutions is shown to be invalid for the liquid junctions $x$MKCl–1·0MHCl and $x$MKCl–0·1MHCl, where $x$ ranges from 0·1 to 4·1 and the temperature is 25°.

There is no contact p.d. at 25° between a saturated solution of potassium chloride (4·1 M) and hydrochloric acid solutions ranging in concentrations from 0·1 molar to 1·0 molar.

In an electromotive force combination having a contact p.d. as one of its component e.m.f.'s, the diffusion across the liquid junction of the one liquid into the other brings about a decrease in the magnitude of the contact p.d., and this decrease may amount to as much as one-tenth of the initial magnitude of the contact p.d. For this reason combinations having only very small or zero contact p.d.'s should be used for precise e.m.f. measurements.

The following values of pole potential differences have been ascertained for the temperature of 25° with a precision probably reliable to ±0·0002 volt:—

| | | | |
|---|---|---|---|
| Hg–HgCl | 1·0MKCl, 0·5648 volt | Hg–HgCl | 0·1MKCl, 0·6168 volt |
| Hg–HgCl | 1·0MHCl, 0·5567 volt | Hg–HgCl | 0·1MHCl, 0·6168 volt |
| Pt–$H_2$(1 atmo.) | 1·0MHCl, 0·2777 volt | Pt–$H_2$(1 atmo.) | 0·1MHCl, 0·2179 volt |

A. F.

**108.** *The Function of Complex Salts in Electrolytic Baths.* **R. S. Dean** and **M. Y. Chang.** (Chem. and Met. Eng. 19. pp. 83–85, July 15, 1918.)—Electrolytic deposits are said to be made smoother and more adherent by the presence of complex salts, because, *e.g.*, the silver is not primarily deposited as ion, but reduced from the AgKCN by the primarily liberated potassium ion which dissolves in the bath; the reduction of the silver would thus be secondary and chemical. Why this chemical deposit should be superior to the electrolytic is not apparent. The authors show that the deposits become more and more amorphous as the solution is diluted. Yet silver oxide stirred into water gave a more crystalline deposit than 0·0001 N-silver nitrate; silver chromate gave no deposit, even in the presence of potassium nitrate, but did so when cyanide was added. Studying the decomposition voltages with the aid of a Leeds-Northrup transition-point potentiometer, they find that the decomposition voltage of $AgK(CN)_2$ depends practically upon the concentration of the potassium ion and bears no relation to the total concentration of silver or to the concentration of silver ion. The deposition of Ag is therefore secondary. The complex salt furnishes a concentrated solution of the metal, but a weak solution of its ion. Crystals tend to grow, and one silver atom tends to deposit on another; if, however, the silver be reduced by the dissolved potassium ion, there is no tendency to any orientation of the silver atoms. That silver gives crystalline deposits on metallic Mg is due to the fact that the first Ag deposit produced forms a voltaic couple with the Mg, so that silver continues to grow on silver. To obtain smooth amorphous deposits of one metal another metal of lower solution tension should be furnished, and a complex salt should be added to ensure that the concentration of the ion of the first metal will be so low, that its discharge voltage will be above that of the second metal. H. B.

109. *The Anode Potential and Liberation of Oxygen.* **G. Grube** and **B. Dulk.** (Zeits. Elektrochem. 24. pp. 237-248, Aug. 1, 1918. Phys. Zeits. 19. pp. 439-440, Oct. 1, 1918. Paper read before the Deut. Bunsen-Gesell., April, 1918.)—The fact that platinised Pt electrodes show an over-voltage when generating oxygen is generally explained by the assumption that platinum oxides are formed and secondarily decomposed under oxygen evolution. In $2N\text{-}H_2SO_4$, in which the anode potential does not exceed $\varepsilon_h = +1{\cdot}6$ volts, the trioxide is present, not in the free state, but in the form of a solution in the unoxidised Pt of the surface. When alternating currents are superposed upon the polarising direct currents the potential of the oxygen-liberation is depressed. With increasing intensity of the alternating current the potential falls without halting through 1·28 to 1 or 1·1 volts, while the oxygen-liberation continues. Since 1·28 volts is the potential of the reversible oxygen-evolution in this acid, oxygen can, at lower potentials, only be liberated by a secondary reaction. When the electrolyte is normal NaOH, a different potential curve is observed. It consists of 3 branches of different slopes: from 1·25 volts—the anode potential of pure d.c. electrolysis—down to 0·7; from 0·7 to 0·42; below 0·42 volt. The three branches probably correspond to different anode processes. In the first branch the oxygen-liberation seems to be connected with an unknown oxide $PtO_x$: in the second branch it is the peroxide; in the third branch some other reaction, probably of hydrogen peroxide, must be responsible for the oxygen evolution, since 0·42 volt is the potential of the reversible oxygen-liberation in normal caustic soda. H. B.